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THE UNIVERSITY OF ALBERTA

ENROLMENT FORECASTING THROUGH ANALYSIS OF STUDENT FLOW

BY

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled ENROLMENT FORECASTING THROUGH ANALYSIS OF STUDENT FLOW submitted by BARRY LANCELOT SNOWDEN in partial fulfilment of the requirements for the degree of MASTER OF BUSINESS ADMINISTRATION

ABSTRACT

This paper reports an analysis of the Alberta system of advanced (post-secondary) education, focussing in particular on student flow related aspects with a view to applying flow modeling techniques to solution of enrolment forecasting and policy evaluation problems. A survey of the literature and state-of-the-art is reported, the participation analysis (demographic ratio) approach is examined and alternative methodologies are described.

Conceptual models of admissions, enrolment and student flow processes are presented and a general mathematical approach to building a system-level model is proposed. It is shown that the approach can be extended to incorporate the effects of student characteristic, system/institutional control and exogenous variables. Data requirements are addressed and questions of evaluation and validation dealt with.

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INTRODUCTION

A basic and primary objective of Alberta's system of higher and further education is the provision, in an effective and an efficient fashion, of access to educational and training opportunities for all those prepared for and desiring participation in post-secondary programs. In addition, the system must be responsive to manpower needs and to the needs of society.

Estimates of future enrolment expectations are essential to rational planning and decision making at all levels in the system. Knowledge of the demand for programs and services; the kinds and numbers of potential students, their needs, their geographic dispersion and their future intentions is a necessity. So too is the capability to forecast future participation levels and trends if informed decisions are to be made with respect to the allocation and utilization of public support at both the provincial and the institutional level. Implicitly or explicitly the formulation of budgets and resource allocation policies at institutions involves enrolment level estimation for at least the budgetary year. Allocations of resources among programs and institutions are dependent, to a large extent, on enrolment based formulae.

In Alberta, as in other jurisdictions, the decade of the 60's experienced unprecedented growth in post-secondary enrolments with commensurate investments in educational facilities and increases in operating expenditures. Full-time enrolments at Alberta universities grew from 8,250 in 1961-62 to 28,990 in 1970-71 and public college

enrolments from 920 to 4,100. During the same period full-time technical institute enrolments increased from 1,620 to 6,260 and participation at regional colleges from 340 to 650. This rate of growth has not continued into the 70's however. The 40,000 full-time student level in 1970-71, increased by only 750 in 1971-72 and by a further 690 in 1972-73, with university enrolments experiencing an absolute decline in each year. As a result, in the past two years an opportunity has been provided to engage in more detailed review of programs and services and to carefully plan for expansions to ensure that in particular segments and/or in total, the system does not expand beyond the demand for services.

In the Fall of 1972, on the recommendation of an ad hoc Committee on Post-Secondary Enrolment created to advise the Minister of Advanced Education with respect to problems in enrolment projection, a study was initiated the purpose of which was to review enrolment and student flow related aspects of the advanced education system, and to assess the feasibility and desireability of utilizing student flow modeling techniques to assist the prediction of flows of students to, within and from post-secondary programs at Alberta institutions. In addition, student information systems and requirements were to be assessed in relation to alternative methodologies including flow modeling. Further, post-secondary participation was to be analysed.

This paper reports the analysis and review. It is organized in the following fashion. Chapter I presents a review of literature and the "state of the art". In Chapter II the Alberta advanced education system is described in relation to student flow and enrolment behaviour. Chapter III reviews participation rates in post-secondary programs. Chapter IV provides an analysis of the system and a conceptualization of the problem. Directions for the formulation of a model are proposed in Chapter V and conclusions offered in a final section.

CHAPTER I

THE LITERATURE

The literature concerned with the application of formal analytical technique to enrolment forecasting has been generated largely since 1960. A review of this literature reveals two major categories of technique: (1) trend extrapolation of historical data and relationships, and (2) system modeling. In addition, a number of explanatory studies are proposed. Trend extrapolations involve the analysis of historical data, the derivation of relationships and the production of extrapolations of preceived trends. System modeling includes the development of both flow and simulation models of educational systems including treatments conceptualizing education as a sub-component of socio-economic systems. Explanatory studies explore the causal relationships operative in higher education. Micro-analytic approaches focus on individual behaviour and the understanding of student decisions with respect to educational, vocational and career choices.

Extrapolation Procedures

In one of the earliest formal treatments of techniques in enrolment forecasting, L.J. Lins[1] identifies four methods: Curve-fitting, Ratio analysis, Cohort-survival analysis and Correlation analysis.

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[1] L.J. Lins, Methodology of Enrolment Projections for Colleges and Universities (Washington, D.C.: American Council on Education, 1960)

The curve-fitting method involves essentially a time series analysis, determining the functional relationship which exists between historical levels of enrolment and time. It has been observed that the assumptions underlying this method are extremely restrictive: that past trends will continue and that new factors will not be introduced.[2] Boling and Gardiner[3] analyse the application of various methods of curve-fitting. A polynomial curve-fitting model is evaluated by Zimmer[4] and he concludes that except for short-range projection, the method rated very low against alternatives available. A considerable attraction to the method, however, is its modest data requirement. Orwig, Jones and Lenning[5] refer to this approach as a trend line model and apply the analysis to enrolment in departments within a university, concluding that the simple and straight forward approach in many instances is just as useful as complex models.

Ratio analysis focuses on the relationship between levels of enrolment in programs or institutions and the population, usually a specified age group. Alternatively referred to as demographic ratio analysis or the participation method, the technique supports rather sophisticated

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[2] R. Allan McLean, A University Enrolment Projection Model, unpublished M.B.A. dissertation, The University of Alberta, 1971.

[3] Edward J. Boling and Donald A. Gardiner, Forecasting University Enrolment (Knoxville: The University of Tennessee, 1952).

[4] John F. Zimmer, An Evaluation of Four Methods of Enrolment Projection as Applied to a State College System, unpublished Ph.D. dissertation, University of Minnesota, 1970.

[5] M.D. Orwig, Paul K. Jones and Oscar T. Lenning, Enrolment Projection Models for Institutional Planning (Iowa City: American College Testing Program, 1972).

studies depending upon the nature and level of stratification and disaggregation of data on such dimensions as sex, level, type, region, etc. Davis[6] outlines this method and detailed procedures for its application are provided by Liu.[7] Ratio analysis is widely used, especially in surveys of educational participation and projection at the national level.[8] The utility of the method in determining potential as opposed to estimated or expected enrolment levels will be discussed fully in Chapter III.

The cohort-survival technique is among the most widely used and can be described as an accounting for the whereabouts of similar groups or cohorts of individuals as they progress through an educational system. The size of a cohort in one year is compared to its size in the next and a survival ratio is derived. Adair[9] describes the approach and its application as a computerized model is reported by Cross and Sederberg.[10]

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[6] Russell G. Davis, Planning Human Resource Development; Educational Models and Schemata (Chicago: Rand McNally Company, 1966).

[7] Bauguee Alfred Liu, Estimating Future School Enrolment in Developing Countries: A Manual of Methodology (New York: UNESCO, 1966).

[8] W.D. Borrie and Ruth M. Dedman, University Enrolments in Australia, 1955-70 (Canberra: Australian National University, 1971); R.W.T. Cowan, Education for Australians (Melbourne: F.W. Cheshire, 1964); Wolfgang M. Illing and Zoltan E. Zsigmond, Enrolment in Schools and Universities 1951-52 to 1975-76 (Ottawa: Queen's Printer, 1967); Edward F. Sheffield, Enrolment in Canadian Universities and Colleges to 1976/76 (Ottawa: Association of Universities and Colleges of Canada, 1966).

[9] C.D. Adair, "Predicting Next Year's Enrolment," School and Community, 55, (1969), 37.

[10] R.H. Cross and C.H. Sederberg, "Computer-Assisted Enrolment Projection Procedures", Journal of Educational Data Processing, 2, (1969), 160-165.

A combined enrolment ratio-cohort survival model is described by Lins[11] and a similar formulation evaluated by Zimmer[12] who concludes that it rates favourably against other methods and the subjective criteria of projection time, availability of data, information yielded and responsiveness to population changes. A major study based upon the cohort-survival method is reported by Thompson.[13]

Correlation analysis involves the application of classical statistical techniques where the objective is to determine the association between enrolment as a dependent variable and one or more independent variables which may be endogenous or exogenous to the education system. Brown and Savage[14] develop various models to determine the number of students in attendance at functions of high school graduates, net changes in armed forces personnel, live births, etc. Sawiris[15] suggests methods utilizing a linear multiple regression technique including deterministic models, stochastic models and models containing both components, and draws conclusions that the utility of any particular method is a function of the number of observations available, the

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[11] Lins, Methodology of Enrolment Projections.

[12] Zimmer, Methods of Enrolment Projection.

[13] Ronald B. Thompson, Estimating College - age Population Trends 1940-1970 (Columbus: American Association of Collegiate Registrars and Admissions Officers, 1954).

[14] B.W. Brown and J.R. Savage, Methodological Studies in Educational Attendance Prediction (Minneapolis: Department of Statistics, University of Minnesota, 1960).

[15] M.H. Sawiris, "The Projection of College Enrolment", Multivariate Behavioral Research, 5, (1970), 83-100.

degree of noise in the data and other factors. Haggstrom[16] demonstrates that the inclusion of information on prior enrolment improves the efficiency of prediction in the case of institutional or system projections. The development of a regression equation including high school graduates, economic activity indicators and population as independent variables is recommended by Wasik.[17]

System Models

Wasik[18] identifies two categories of models in the class of technique which we have termed system models: (1) structural flow models which quantify structural relationships among factors in the system and (2) Markov-type models. Additionally, we include simulation approaches and those which recognize the dynamic inter-relationship of education and the economy.

A structural model, utilizing a system of differential equations, including a feedback element to dynamically depict inflows and outflows of participants in professional programs, has been described by

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[16] G.W. Haggstrom, "On Analysing and Predicting Enrolments and Costs in Higher Education", Proceedings of the Social Statistics Section, J.A.S.A., (1969).

[17] J.L. Wasik, "The Development of a Mathematical Model to Project Enrolments in a Community College System" (paper presented at American Educational Research Association annual meeting, March, 1971).

[18] J.L. Wasik, A Review and Critical Analysis of Mathematical Models Used For Estimating Enrolments in Educational Systems (Raleigh, North Carolina: North Carolina State University, 1971).

Bolt, Koltan and Levine.[19] Reisman[20] has developed a model, using the Forrester[21] social systems simulation methodology, encompassing four educational production sectors - undergraduate, master, doctoral and post-doctoral. Oliver and Hopkins[22] develop a "constant work" model for a university campus using a structural steady state flow concept and incorporating a feedback loop whereby graduate teaching assistants and doctoral graduates are both inputs and outputs to the system. With Armacost,[23] they further propose a network flow model of the student-faculty interface in the only study identified attempting to apply network theory. Koenig _et al_,[24] in a major study develop a student flow model as a sub-component of a larger resource allocation/costing model and extend their formulation conceptually to the larger economic

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[19] R.H. Bolt, W.L. Koltan, and O.H. Levine, "Doctoral Feedback into Higher Education, _Science_, 148, (1965), 918-928.

[20] A. Reisman, "Higher Education: A Population Flow Feedback Model". _Science_, 153, (1966), 89-91.

[21] J.W. Forrester, _Industrial Dynamics_ (Cambridge: M.I.T., 1961).

[22] Robert M. Oliver and David S.P. Hopkins, "An Equilibrium Flow Model of a University Campus", _Operations Research_ (March - April, 1972), 249-264.

[23] R.M. Oliver, D.S.P. Hopkins and R. Armacost, "An Academic Productivity and Planning Model for a University Campus". (Report #3, University of California Administrative Studies Project in Higher Education, 1970).

[24] Herman E. Koenig, M.G. Keeney and R. Zemach, "A Systems Model for Management Planning and Resource Allocation in Institutions of Higher Education". (East Lansing, Michigan: Michigan State University, 1968).

system. The CAMPUS Model[25] developed by Systems Research Group involves a student flow model in a similar context.

An early application of Markov Chain theory to the flows of students in educational systems is reported by Brown and Savage[26] where transition matrices are empirically calculated and used to describe flows between faculties and majors in a university context. In the Markov process, subjects within a population are stratified into a set of mutually exclusive categories or "states". These states may include various levels or grades of study, at an institution, in a faculty or program. Transition probabilities or proportions are calculated for subjects who, having been in a particular state at one time period, are in the same or a different state in the next period. Gani[27] applies the method to the projection of enrolments and degrees in Australian universities. Stone[28] utilizes the technique in developing a conceptual model for the British educational system within an economic model which accounts for demand for educational places, the influence of economic inputs to the educational process and technological change. This

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[25] Richard W. Judy, J.B. Levine and S.I. Canter, CAMPUS V Documentation, (Vols. 1 - 6, Toronto: Systems Research Group, 1970).

[26] Brown and Savage, Methodological Studies.

[27] J. Gani, "Formulae for Projecting Enrollments and Degrees Awarded in Universities", Journal of the Royal Statistical Society, Series A, 126, (1963), 400 - 409.

[28] Richard Stone, "A Model of the Educational System", Minerva III 2, (Winter, 1965), 172 - 186.

formulation is refined in a later paper.[29]

A mathematical structure providing the basis for a computer simulation of the flows of students through educational and employment systems in Ontario is described by Clough and McReynolds.[30] A "constraint theory of supply and demand" describes the mathematical structure of decisions and policies affecting the systems. Thonstad[31] develops a Markovian mathematical model of the Norwegian educational system and Armitage et al[32] use a similar approach in modeling the upper secondary component in Britain.

The transition coefficient approach to a simulation model is evaluated by Baisuck and Wallace[33] who observe that many of the models designated by their builders as Markov Models procedurally resemble one type of Markov chain and therefore coin the term "Markov-type". They conclude that the computer model offers opportunity to the planner and decision maker to incorporate and evaluate alternative sets of

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[29] Richard Stone, " Input-Output and Demographic Accounting: A Tool for Educational Planning", Minerva, IV, 3, (Spring 1966), 365-380.

[30] Donald J. Clough and William P. McReynolds, "State Transition Model of an Educational System Incorporating a Constraint Theory of Supply and Demand", Ontario Journal of Educational Research, 9, 1, (Autumn, 1966), 1-18.

[31] Tore Thonstad, Education and Manpower: Theoretical Models and Empirical Applications, (Toronto: University of Toronto Press, 1968).

[32] Peter H. Armitage, Celia M. Phillips and Judith Davies, "Towards a Model of the Upper Secondary School System", Journal of the Royal Statistical Society, Series A, 133, (1970), 166-192.

[33] Allen Baisuck and William A. Wallace, "A Computer Simulation Approach to Enrollment Projection in Higher Education", Socio-Economic Planning Sciences, 4, (1970), 365-381.

assumptions. Zimmer[34] reports a similar evaluation concluding that both subjectively (adaptability, changeability, manpower effectiveness) and objectively (error, cost, # of variables) the Markov-type model rates favourably. He recommends that of available and relatively unsophisticated techniques, greatest emphasis be placed on Markov-type and survival-growth ratio analysis. McLean[35] agrees but shows that the latter is a special case of the former.

Further description and evaluation of the Markov-type formulation will be undertaken in Chapter V.

Explanatory and Micro-analytical Studies

Explanatory and micro-analytical studies are characterized by their focus on causal relationships and their basis in cognitive, behavioural or economic theory. Orcutt *et al*[36] explore the areas of micro-analysis and simulation of the United States socioeconomic system. They identify the need for reliable prediction of demand in higher education and explore a number of hypotheses including postulations that probability of attendance is sex dependent, that father's education and occupation is an independent variable, that high-school ability and achievement is relevant and that geographic proximity of opportunity is an indicator.

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[34] Zimmer, *Methods of Enrolment Projection*.

[35] McLean, *A University Enrolment Projection Model*.

[36] Guy H. Orcutt, Martin Greenberger, John Korbel and Alice M. Rivlin, *Microanalysis of Socioeconomic Systems*: A Simulation Study, (New York: Harper and Brothers, 1961), 257-284.

Further study in attitudinal and economic consideration areas is recommended. Corcoran and Anderson[37] differentiate macro-analytical studies from the micro-analytical approach and propose a micro-model based upon synthetic enrolment histories developed on the basis of hypothetical behavioural relationships. A dual approach through which micro-analytical studies "inform" macro-model approaches to forecasting and trend estimation is recommended. Weathersby[38] provides a review of projects and studies focussing on the United States experience.

A major comprehensive study in the Canadian context is reported by Breton.[39] The study is based on a conceptual framework summarized in the following:

> "..... an adolescent's career development and, more specifically, his intentions and decisions with respect to his future career, depend on three interrelared sets of factors: his social origin; his present experience; and his attitudes (expectations, sense of efficiency) and preparedness (information, competence to deal with organizational environments) with respect to the future. While it must be reiterated that these sets of factors are interrelated, it should also be pointed out that in some ways they are somewhat autonomous".[40]

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[37] Mary Corcoran and Douglas H. Anderson, "Rationale for Using Micro-analytic Approaches in Predicting the Character and Size of College Student Enrollments". Institutional Research and Academic Outcomes. (Courtland, N.Y.: Association for Institutional Research, 1968), 53-59.

[38] George B. Weathersby, "Tools and Techniques for Planning and Resource Allocation". Planning and Management Practices in Higher Education: Promise or Dilemma? (Denver: Education Commission of the States, 1972), 77-96.

[39] Raymond Breton, Social and Academic Factors in the Career Decisions of Canadian Youth, (Ottawa: Information Canada, 1972).

[40] Ibid., 3.

The results of the study confirmed that educational intentions are related to the socioeconomic background of the student, that the set of individuals with whom a student associates exert significant influence and the educational institution as a formal organization and the adolescent's experience with it have an effect on career development, preferences and intentions.

Handa and Solnik[41] undertake a survey of analysis of demand for education in Canada and after reviewing various micro-analytical models relating educational attendance to economic variables including a price model, conclude that the absolute value of price elasticity of demand for education may be greater than unity and that generally, employment prospects have a significant effect on retention rates. The relationship between education and occupation is explored by Sewell.[42] Hettich[43] focusses on educational activity as consumptive behaviour and draws on consumer choice theory regarding to the behaviour attributed to the rational economic decision-maker (involving utility and pay-off determination). Simply stated, the decision-maker will balance the costs of any alternative, plus the costs of reaching a decision against the gain in expected utility and equate marginal costs to expected marginal benefits. Improvements in the information repetoire available to the

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[41] M.L. Handa and M.L. Solnik, "Empirical Analysis of the Demand for Education in Canada", in Canadian Higher Education in the Seventies edited by Sylvia Ostry (Ottawa: Information Canada, 1972), 5-44.

[42] David Sewell, "Educational Planning Models and the Relationship between Education and Occupation", in Canadian Higher Education, 45-74.

[43] Walter Hettich, "Consumption Benefits from Education", in Canadian Higher Education, 177-198.

education consumer are recommended.

Stager,[44] in an examination of resource allocations in Canadian education develops a model for estimating social and private net present values attributable to continuing educational participation beyond high school. An application of Irving Fisher's work on consumption over time is reported by Schaafsma.[45] Models are postulated for determining time spent by the effects of changes in costs, in patience, and the effects of borrowing, of gifts. On the basis of empirical tests, the positive conclusion that more vigorous and detailed work is warranted is reached.

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[44] David A.A. Stager, "Economics of Continuing Education in the Universities", in Canadian Higher Education, 265-290.

[45] J. Schaafsma, "The Demand for Higher Education in Canada", (unpublished paper, University of Toronto, September 1968).

Observations

A number of observations can be made with respect to the state of the art as reflected in the literature. First, the popularity of any particular explanatory or system modeling technique would appear to be more associated with the ease of application of a technique than structural or behavioural validity. The relatively simple and straight forward methods predominating in practice turn out many comprehensive and useful studies. The scarcity of studies dealing with the development and/or application of sophisticated techniques would appear to have two basic explanations: (1) the real world variables involved would appear to be too complexly interrelated to permit an adequate representation; (2) the data base available and foreseeable is too inadequate. The proponents of some of the most promising techniques admit that the required data was not, and may not ever be available.

The exploration of increasingly complex methodology has roughly paralleled three trends: (1) the phenomenal increase in participation in post-secondary programs in the past decade and the tremendous increase in numbers, (2) the increasing concern regarding accountability in resources utilization and (3) the increasing availability to researchers of the hardware and software necessary to exploration and application in this area.

Few of the methods or models proposed or in use recognize variables which are within the direct control of policy makers, and few recognize the interdependence among enrolment levels, potential levels and policies.

CHAPTER II

SYSTEM COMPOSITION

The Alberta system of Advanced Education includes twenty-two publicly supported institutions: four universities, a centre for fine arts and continuing education, six public colleges, three regional (agricultural and vocational) colleges, two technical institutes, five vocational training centres and a specific technology training institution, located as shown in Figure 1. These institutions offer a diversity of higher and further education programs including undergraduate, professional and graduate university education; university preparatory and transfer programs; career, vocational and technical training; upgrading and compensatory education; and continuing education and public service programs to the public at large.

In undertaking the enrolment projection - student flow project, the investigator was given the opportunity to visit and interview officials at Alberta's universities, public colleges and technical institutes, one of the regional colleges and one of the vocational centres; officials of the Provincial Departments of Education and Advanced Education and personnel at two coordinating commissions. In addition to familiarizing the investigator with the system of Advanced Education, these visits focussed on such questions as: (1) What is the importance of enrolment and student flow information, (2) What policy areas and variables are involved, (3) What data are available within the system, (4) What methodological expertise is available, and (5) what resources are available?

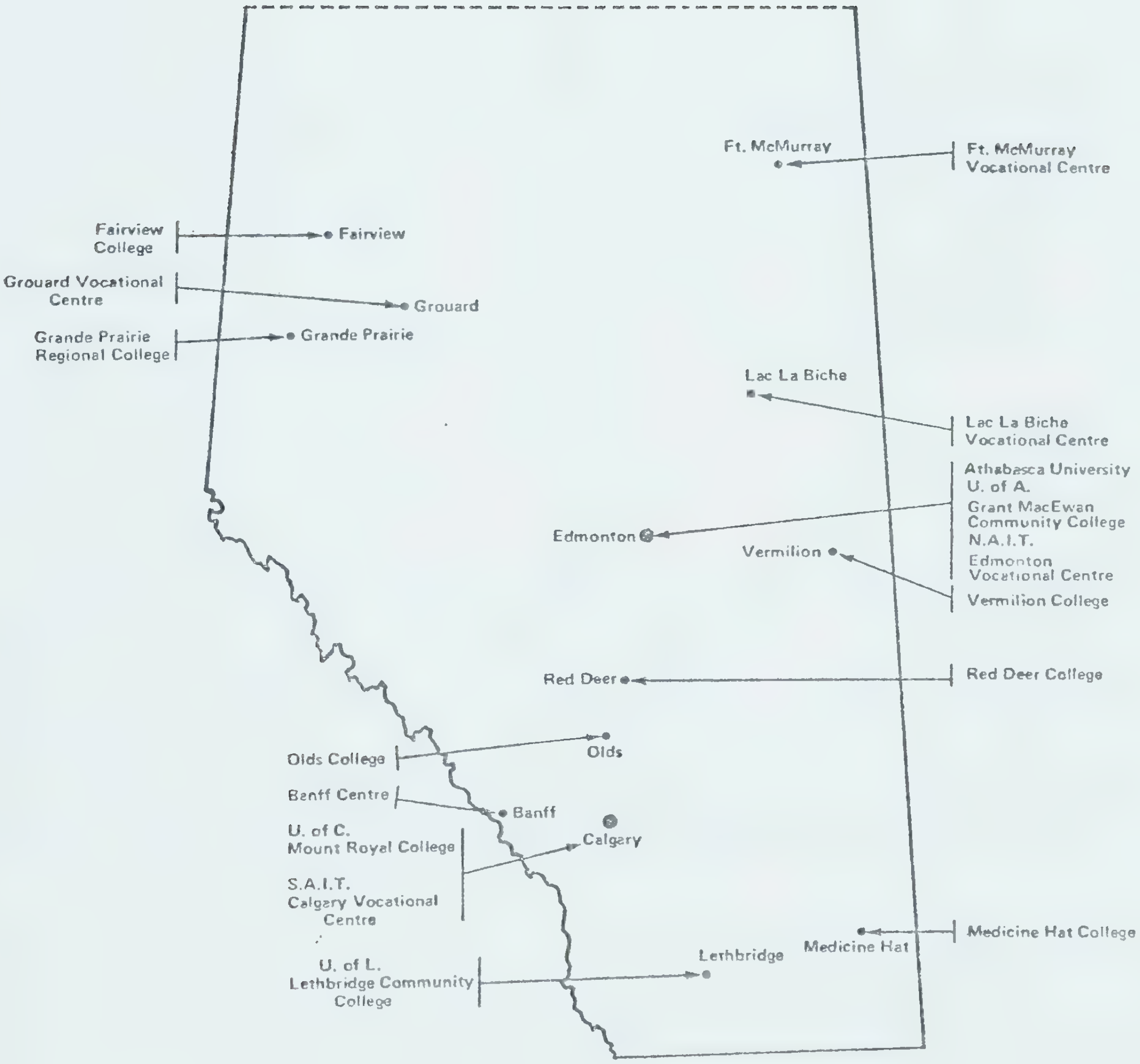

FIGURE 1

Advanced Education Institutions in Alberta

This chapter presents some of the data and information gathered through a combination of these visits and the researching of such documents as calendars and annual reports. In addition, recent studies of the system provided valuable insight.[1]

Universities

Three of Alberta's four universities offer undergraduate programs in Arts, Science and Education. Two of these have well developed graduate and professional programs. Alberta's fourth university is experimental in nature, charged with planning development of alternative instructional and program delivery methods. Information regarding university programs is provided in Table 1.

The University of Alberta

Programs offered at Alberta's oldest and largest university are described in columns 2 and 3 of Table 1. Enrolment in the University's 16 faculties and schools totalled 17,757 full-time students in 1972/73 with a further 9,353 enrolled as part-time students or in summer session programs. The University has affiliation agreements with Grande Prairie

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[1] W.H. Worth, A Choice of Futures - Report of the Commission on Educational Planning, (Edmonton, Queen's Printer, 1972); R.A. Bosetti, Master Plan #1 - The Alberta System of Post-Secondary Non-University Education, (Edmonton, Alberta Colleges Commission 1972).

Table 1

Current Programs at Alberta Universities and Length of Programs[1]

Program	Alberta		Calgary		Lethbridge
	Under-Grad	Graduate	Under-Grad	Graduate	Under-Grad
(1)	(2)	(3)	(4)	(5)	(6)
Non-Professional[2]					
Agriculture/Forestry	4	M,D			
Arts/Fine Arts	3,4	M,D	3,4	M,D	4
Business/Commerce	4	M	4		
Dental Hygiene	2				
Education	4,2[3]	M,D	4,2[3]	M,D	4,2[3]
Engineering	4	M,D	4	M,D	
Household Economics	4	M			
Medical Lab. Science	4				
Nursing	4				
Pharmacy	4	M,D			
Physical Education	4	M,D	3		
Rehab. Medicine	2,3,4				
Science	3,4	M,D	3,4	M,D	4
Social Welfare				M	
Professional[2]					
Dentistry	4	M			
Environmental Design				M	
Law	3	M			
Library Science	1				
Medicine	4	M,D			

Source: University Calendars - 1972/73.

Notes:
1. Figures in columns 2, 3 and 6 indicate length of program in years. "M" = masters; "D" = doctoral. No entry indicates that program not offered.
2. "Professional" programs require a previous degree or pre-professional study.
3. Education degree program "after previous degree".

Regional College and Red Deer College, providing for the continuation of one and two year transfer programs in a number of faculties, and recognizes credits for university level work at other colleges with university transfer programs.

Residential accommodations are provided on campus for 2,150 single students in residence halls, a 300 unit married and family housing complex is currently under expansion and additional residential facilities are provided through a Student Union sponsored and developed project. Extensive student services programs are maintained by the University.

Although major program additions do not appear likely in the immediate future, the apparent direction for the University's development is toward concentration on senior undergraduate, professional and graduate programs.

The University of Calgary

The University of Calgary offers undergraduate, professional and graduate programs through eleven faculties and schools. The extent of these programs is described in columns 4 and 5 of Table 1. Enrolments in 1972/73 were 8,780 full-time and 6,195 part-time. The University has affiliation agreements for one and two year transfer programs with Mount Royal College. In addition, students transferring from other institutions are granted credit for university level courses completed on an individual basis.

Residential accommodations include on campus facilities for 800 single students with an additional complex providing for 250 married student families. Student services programs and facilities are comparable to those at the University of Alberta.

Continued development of undergraduate, professional and graduate programming is anticipated at the University of Calgary.

The University of Lethbridge

The University of Lethbridge was established in 1967 and offers four year degree programs in Arts, Science and Education as well as a variety of basic pre-professional and professional transfer programs. in 1972/73, there were 1,076 full-time students and 1,302 part-time and summer session students enrolled.

Unlike the Universities of Alberta and Calgary which operate on term-session calendars, the University of Lethbridge organizes offerings on a semester basis, providing for a major entry of new students in January as well as September.

Residential accommodations are available for 400 students and are uniquely integrated within the campus's main academic building. Student services programs are provided on a relatively comparable basis with other Universities, although relative sizes and economies of scale explain certain limitations.

Future program developments at the University will likely include such areas as management studies and expansion of pre-professional and professional transfer courses where demand warrants. Limited graduate programming is not inconceivable, however, the University of Lethbridge is expected to continue to offer the alternative of a smaller, more intimate atmosphere than other campuses.

Athabasca University

Athabasca University was originally established by an order-in-council of the provincial legislature in 1970 and was given an academic and physical planning charge and a program mandate in the areas of undergraduate arts, science and education. Recent declines in student demand for programs in these areas has necessitated a moratorium on the University's planning and physical development. A new order-in-council:

> "empowers and authorizes the Athabasca University Interim Governing Authority to undertake a pilot project for the production, testing and application of learning systems to provide study programs in the arts and sciences leading to an undergraduate degree, and for the application of technology and new procedures to improve educational opportunities generally."[2]

Banff School of Fine Arts

The Banff School of Fine Arts and Continuing Education is a special purpose institution offering short duration programs in fine and performing arts areas and in such other areas as appropriate given the institution's capabilities and setting. The School operates the Banff School of Advanced Management and hosts seminars and conferences on a year round basis.

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[2] Government of Alberta, Order-in-Council #1986 , 1972.

Public Colleges

Alberta's public college system consists of six publicly-supported institutions whose programs are designed to provide education and training to students representing a wide range of interests, aptitudes and ambitions. Programs have been developed to provide opportunities for university transfer education, career and vocational training, compensatory training and upgrading and continuing education for adults. Table 2 summarizes information regarding program availability and duration at the colleges. Enrolments in 1973/74 are summarized in Table 3.

Grande Prairie Regional College

Established in 1965 as a regional institution, Grande Prairie Regional College, through affiliation with the University of Alberta, provides first year university transfer programs to residents of the Peace River area. A second major program area provides one year "Certificate" and two year "Diploma" programs in Business Administration and Secretarial Science. Other program areas include upgrading and compensatory education and a number of *ad hoc* courses, provided in response to specific practical or regional demands. The College operates on a semester system.

Completion of a new campus and generally rising demand for programs in the region point to an expanded role for the College. The institution of second year transfer programs and the development of first year technology, health and allied services, community services and special interest programs are probable future developments. Other potentials for development involve cooperative linkages with Fairview College near Peace River and the further extension of programs to the region.

Table 2

Current Programs at Alberta Public Colleges and Length of Programs[1]

Program (1)	Grande Prairie Regional College (2)	Grant MacEwan Community College (3)	Red Deer College (4)	Mount Royal College (5)	Medicine Hat College (6)	Lethbridge Community College (7)
Academic Upgrading	x		x	x	x	x
Agricultural Technology				2		2
Applied Arts and Sciences		2	2	2	1	
Business & Administration	1,2	2	1,2	1,2	1,2	1,2
Communications/Journalism		2		2		2
Community Services[2]		2		2		2
Health & Allied Services		2	2	1,2	2	1,2
Home Economics		2		2	1	1,2
Industrial Technology						1
University Transfer	1					

Source: The Alberta Colleges Commission.

Notes:
1. Figures in columns 2 through 7 indicate length of program in years. Where institutions operate on a semester or trimester system, one year is the equivalent of two semesters/trimesters. "x" indicates program availability.
2. Community Services includes such programs as library assistant training, recreation administration, police science, etc.

Table 3

Full-time Enrolment at Alberta Public Colleges
Fall - 1973/74

Program	Year	Grande Prairie Regional College	Grant MacEwan Community College	Red Deer College	Mount Royal College	Medicine Hat College	Lethbridge Community College
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Diploma, Certificate and other	1	160	700e	271	139e	145e	800e
	2	-	300e	79	435e	5e	190e
	Total	160	1,000	350	1,825	150	990
University Transfer	1	115	-	223	480	150	-
	2	-	-	92	-	50	-
	Total	115	-	315	480	200	-
Total Full-time	1	275	700	494	1,870	295	800
	2	-	300	171	435	55	190
	Total	275	1,000	665	2,305	350	990

Source: College Reports.

Notes: 1. "e" = estimate

Grant MacEwan Community College

Grant MacEwan Community College was established in 1971 as a complement to the University of Alberta and the Northern Alberta Institute of Technology in the Edmonton region. Current program availability is described in column 3 of Table 2. The College operates on a trimester calendar system under which students may be admitted to programs at three points during the year. At this time, however, not all courses of study are offered in each trimester.

The College provides a wide variety of student services including placement services and health services on a referral basis. Although residential accommodations are not provided, a listing service and information exchange is available.

Program expansion is anticipated for the College across a wide variety of program areas, including combined university preparatory - university transfer programs and certain programs to receive transferring students from other institutions. Cooperative relationships and linkages may be developed with other institutions, Vermilion College and Ft. McMurray Alberta Vocational Centre in particular.

Red Deer College

Red Deer College was established in 1964 and, through an affiliation agreement with the University of Alberta, offers first year university transfer programs providing admission to ten faculties and schools and second year programs for transfer to five. These and the additional programs described in column 4 of Table 2 are offered on a term-session calendar basis.

Student services programs are well developed and include financial aid advisement, scholarships and awards, job placement services and housing. A new residential complex provides accommodations for single and married students.

Program developments proposed for the College include expansions of general and career programs in technology areas, the arts, community services and home economics. Transfer arrangements may be extended to provide for articulation with Technical Institutes and urban Colleges. Combined programs with other institutions have also been proposed.

Mount Royal College

In 1966, Mount Royal College, previously a private church related institution, became part of the Alberta Colleges system and in the same year, entered into an affiliation agreement with the University of Calgary. The College offers programs providing for transfer after one year to nine University faculties and schools. Two year transfer programs are available in five areas. In addition to the programs described in column 5 of Table 2, the College operates the Old Sun campus at Gliechen, to meet the specific needs of the Blackfoot Indian Band. Mount Royal College operates on a semester system and offers University transfer programs on a Spring-Summer calendar beginning in February and concluding in August.

A diversity of student services are provided including comprehensive counselling and advisement, health services and day care services. Housing accommodations are not provided.

The College is expected to continue its development of a comprehensive post-secondary program including articulations with other non-university institutions providing for student transfer and continuation of study.

Medicine Hat College

Medicine Hat College is a multi-purpose institution meeting the needs and career aspirations of students in the southeast area of the province offering, through an affiliation agreement with the University of Calgary, first and second year transfer programs and, in addition, one and two year "Certificate" and "Diploma" programs in various career areas. Specific program information is provided in Table 2. The College operates on a semester system calendar.

The usual student services are offered with the exception of student housing.

Future program plans include an expansion of career offerings in such areas as community services, vocational and technical programs and continuing education. Music and the fine and performing arts may receive greater attention and transfer programs may be arranged with Technical Institutes and urban Colleges.

Lethbridge Community College

More than 30 "Certificate" and "Diploma" programs are offered through six divisions and schools at Lethbridge Community College. The College operates on a semester system and offers a substantial summer program.

Student services at the College are well developed and although residential accommodations are not presently available, planning is underway for a complex to provide for 200 students and to facilitate the further development of hospitality industry instructional programs.

A continued development of the College's comprehensive program offering is anticipated with the inclusion of first year transfer programs to Technical Institutes in selected areas. Similar developments may occur in Agricul-

tural Technologies with Olds College and in the Health Services and Allied Careers area with Mount Royal College.

Agricultural and Vocational Colleges

Alberta's Advanced Education system includes three Agricultural and Vocational Colleges, administered by the Department of Agriculture until 1972 when responsibility for these post-secondary educational institutions was transferred to the Department of Advanced Education. Fairview College, Vermilion College and Olds College offer academic and vocational programs with specialties in those areas which relate to agriculture and agricultural industries. Current program and enrolment information (1972/73) is summarized in Table 4.

With respect to the future, it has been recommended that Olds College be designated a special purpose institution providing further two-year programs in agricultural technologies, marketing and management, with an expanded role in agricultural extension. Fairview and Vermilion Colleges can be expected to continue to offer programs commensurate with regional needs

Table 4

Full-time Enrolment at Agricultural and Vocational Colleges[1]

Program Area (1)	Fairview College (2)	Vermilion College (3)	Olds College (4)
Academics & Upgrading	41	3	27
Agricultural & Technological	44	112	341
Business & Administration[2]	16	15	45
Home Economics[3]	-	12	49
Total Full-time	101	142	462

Source: College reports.

Notes:
1. Enrolments as of January 31, 1973.
2. Includes Secretarial Arts.
3. Includes Fashion Merchandising.

and institutional capabilities while developing further articulating relationships with other non-university post-secondary institutions.

Technical Institutes

Two Institutes of Technology are included in Alberta's complement of post-secondary institutions, the Northern Alberta Institute of Technology, located in Edmonton and the Southern Alberta Institute of Technology, located in Calgary. Each offers a wide diversity of programs in industrial, trades and health services technologies, communications arts, home economics, business and administration, and service careers areas. Detail with respect to program offerings is summarized in Table 5. Enrolments at the Northern Alberta Institute of Technology in 1972/73 were 4,088 full-time students in regular "day" programs and 4,694 in apprenticeship training courses. An estimated 100 students participated in correspondence programs and 11,121 attended continuing education courses sponsored by the institution. Southern Alberta Institute of Technology enrolments included 3,409 full-time students in "day" programs, 3,351 in apprenticeship courses, 3,917 in correspondence courses and 8,654 in continuing education. Substantial numbers of students are sponsored by such agencies as Canada Manpower. The Institutes operate on a winter session basis with new admissions possible to selected programs in January.

A number of the regular "day" programs at the Technical Institutes operate on a quota basis as facilities and resources permit and as demand for graduates is manifested. Programs in this category are planned and operated with the assistance of advisory committees composed of competent, recognized representatives of the various technological areas and potential employers. These committees advise the Institutes with respect to program content, monitor outputs and the maintenance of quality in keeping with the needs of industry

Table 5

Current Programs at Alberta Institutes of Technology and Length of Programs[1]

Program (1)	N.A.I.T. (2)	S.A.I.T. (3)
Art		
Advertising Art		4
Fine Art Painting		4
Fine Art Sculpture		4
General Crafts		4
Pottery & Ceramics		4
Business Administration		
Bank Teller Training	1	
Business Administration	2	2
Food Services Mgnt.		2
Graphic Arts Mgnt.		2
Hotel, Motel Mgnt.		2
Merchandising Admin.	2	2
Secretarial Science	2	2
Communications		
Broadcasting Tech.		2
Journalism		2
Radio-T.V. Arts	2	2
Community Services		
Library Technology		2
Recreation Management		1
Health Services		
Dental Assistant	1	1
Dental Lab. Tech.	2	
Dietary Svcs. Tech.	2	2
Med. Lab. Tech.	2	2
Medical Records	2	1
Medical Secretarial	1	
Respiratory Tech.	2	2
X-ray Technology	2	
Home Economics		
Commercial Baking	1	1
Commercial Cooking	2	2
Food Technology	2	
Serving	3	3
Specialty Cooking		1

Program (1)	N.A.I.T. (2)	S.A.I.T. (3)
Industrial & Technical		
Aeronautical Eng. Tech.		3
Air Cond. & Refrigeration	2	2
Aircraft Maintenance		2
Architectural Tech.	2	2
Automotive Service		2
Building Construction	2	
Chemical Technology	2	2
Civil Technology	2	
Commercial Signs	1	
Computer Technology	2	2
Diesel Mechanics		1
Drafting Technology	2	2
Electrical Technology	2	2
Electronic Technology	2	2
Exploration Technology	2	
Forestry	2	
Heavy Duty Equipment	2	
Industrial Eng. Tech.		3
Industrial Pdn. Tech.	2	
Instrumentation	2	
Materials Tech.	2	
Machanical Tech.		2
Millwork & Carpentry	1	
Office Machines	1	
Petroleum Tech.		2
Photographic Tech.	2	
Plastics Technology	2	
Power Engineering		2
Structural Tech.		2
Surveying Tech.	2	2
Telecommunications	2	3
Welding	x	x
Apprenticeship		
Technical Preparatory	x	x

Note: 1. Figures in columns 2 and 3 indicate the length of program in years.

and employers in addition to providing information regarding demand for qualified manpower in particular areas.

Student services at the institutions include academic, personal, vocational and financial counselling, health services, placement services and student affairs advisement. Residential accommodations are provided on the S.A.I.T. campus.

Future program developments at the Technical Institutes can be expected in areas related to the petroleum industry, transportation and communications technology, the environment and resource development areas. Co-operative program developments and transfer of credit arrangements with other post-secondary institutions are likely.

Alberta Vocational Centres

The Province, through the Department of Advanced Education, operates five Alberta Vocational Centres offering programs especially designed for adult Albertans seeking educational upgrading, training and/or retraining in vocational and skill areas in preparation for re-entry to the labour force. Centres are located at Fort McMurray, Grouard, Lac La Biche, Edmonton, and Calgary, each catering to the unique demands of their particular situation. Students enter or are placed in Vocational Centre programs in a variety of ways including sponsorship by Canada Manpower or through provincial training programs, referral from the Departments of Health and Social Development, Northern Affairs, Manpower and Labour or federal Indian Affairs or through other training and assistance programs. Although these Centres provide initial courses in programs which may be continued at other institutions, because of the shorter term nature of programs they are not considered further in this study.

Petroleum Industry Training Centre

The Alberta Petroleum Industry Training Centre offers specific technology courses and programs if varying length preparing students for employment in the petroleum industry. Because of the varying nature and length of programs and courses, the A.P.I.T.C. has been excluded from the study.

Coordination and Governance

The institutions described in the foregoing may be divided into two categories: those which are administered through boards of governors and those which are administered and operated directly by the Province. Universities and Public Colleges fall into the former category and Regional Colleges, Technical Institutes, Vocational Centres and the Petroleum Industry Centre into the latter. The board-administered institutions have direct responsibility for resource acquisition, allocation and planning and management functions. For the provincially-administered institutions, considerable responsibility for these functions is carried by the Department of Advanced Education.

The Department of Advanced Education has as a basic purpose "provision of the leadership, service, and coordination necessary to ensure the efficient development and functioning of an effective system of advanced education responsive to the needs of all Albertans".[3]

Major functions of the Department include the following:

1) to secure, allocate, and ensure the efficient use of resources for the system

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[3] Department of Advanced Education, "Reorganization of the Department of Advanced Education", an unpublished policy paper, approved by the Executive Council of the Government of Alberta, January 1973.

2) to identify and monitor needs and establish system wide goals

3) to engage in short and long-range system-level planning and policy development

4) to provide for program coordination and system monitoring

The performance of these and additional functions requires an efficient and effective system and methodology for monitoring and predicting student flows, for evaluating the effects of alternative assumptions and policies and for forecasting enrolment demand. Such a capability should, in addition, be of considerable benefit to institutions and to those involved with resource acquisition, allocation and utilization planning and decision making at the institutional level.

CHAPTER III

THE PARTICIPATION APPROACH

A widely used indicator of levels of enrolment in post-secondary programs and institutions is the ratio of full-time enrolment to a defined age group of the population. Known as the "participation rate", the ratio is commonly calculated by expressing total full-time enrolment in programs in a particular sector (i.e. universities, community colleges, technical institutes, etc.) as a proportion of the number of persons aged 18 to 24 in the population. Other ratio systems used include (1) undergraduate enrolment as a proportion of the 18 to 21 age group and graduate as a proportion of the 22 to 24 group and (2) enrolments in a particular age group as a proportion of the population in the same group. Although the latter provides a more accurate index of "propensity to participate" in educational programs its data requirements are more extensive than can usually be satisfied at a regional, provincial or national level.

An application of the participation approach to enrolment growth patterns at the national level has been undertaken by Sheffield.[1] Based on population projections and assumptions with respect to future

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[1] Edward R. Sheffield, Enrolment in Canadian Universities and Colleges to 1976/77, (Ottawa: Association of Universities and Colleges of Canada, 1966).

participation rates, a forecast of undergraduate and graduate full-time and part-time enrolments at Canadian universities is reported.

Participation analysis has been used extensively in post-secondary educational planning in Alberta. Enrolment forecasts prepared by staff of the Alberta Universities Commission in the late 1960's were based on the approach.[2] Using similar methodology, Chamchuk describes regional participation in post-secondary programs in the Fall of 1971.[3] Analyses of population parameters with a particular focus on implications for the Alberta post-secondary, non-university system development are also reported by Chamchuk.[4] In reporting a master planning project coordinated by the Alberta Colleges Commission, Bosetti advocates the use of the participation approach in a normative sense.[5] Given such factors as population composition, mobility and growth and system policies for the provision of post-secondary services and opportunities on a geographically decentralized basis, participation assumptions are used to establish minimum enrolment objectives which in turn are used to guide program planning. This approach is particularly attractive in recognition of the absence of complete data with respect to client motivations, future economic developments, manpower development policies and other

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[2] Alberta Universities Commission, unpublished staff report on enrolment forecasts.

[3] N.J. Chamchuk, "Regional Participation in Post-Secondary Education in Alberta, Fall, 1971", unpublished report of the Alberta Colleges.

[4] ————————, Population Analyses: Alberta and Regional Population Parameters for Educational Projection and Planning, (Edmonton: Alberta Colleges Commission, 1972).

[5] R.A. Bosetti, Master Plan #1 - The Alberta System of Post-Secondary Non-University Education, (Edmonton: Alberta Colleges Commission, 1972).

factors influencing the nature and extent of participation. The approach does not, however, obviate the necessity of developing a forecasting and monitoring capability to enable institutions and the coordinating Department to recognize and respond to population dynamics, demand trends and student flows to assure responsiveness of the system to the demands of its constituents.

This chapter reports an analysis of historical patterns of participation on a provincial and sub-provincial basis, satisfying one of the terms of reference for the study and, in a particular way, providing a description and analysis of the system.

Provincial and Sub-Provincial Population

A summary description of the Alberta population by selected age group is provided in Table 6 for the census years 1961, 1966 and 1971. For each age group, the area of educational participation most closely related is identified. Over the decade 1961 to 1971, population in the 18 to 24 age group increased by 60 percent while total population in increased by 22 percent. This age group is expected to continue to increase, the rate of increase is expected to decline until the early 1980's when an absolute decline may be experienced.

An analysis of provincial population by census division is provided in Table 7. The location and extent of each census division is shown in Figure 2. Although census divisions do not have official names, they have been added to Figure 2 to facilitate the recognition and location of each. The 18 to 24 components of census division population are shown in Table 8. Since data for 1961 was not readily available in a form permitting reaggregation on a census division basis in the 18 to 24

Table 6

Alberta Population by Selected Age Groups - 1961 to 1971 - Numerical and Percentage Distributions

Age Group	Participation Area	1961	1966	1971
(1)	(2)	(3)	(4)	(5)
0-5	Early Education	213,290	210,464	184,000
6-17	Basic Education	317,744	368,303	431,400
18-24	Higher Education	126,248	163,003	202,250
25-64	Further Education	581,384	617,423	691,475
65+	Further Education	93,278	104,010	118,750
Total	-	1,331,944	1,463,203	1,627,875
0-5	Early Education	16.0	14.4	11.3
6-17	Basic Education	23.8	25.2	26.5
18-24	Higher Education	9.5	11.1	12.4
25-64	Further Education	43.6	42.2	42.5
65+	Further Education	7.0	7.1	7.3
Total	-	100.0	100.0	100.0

Source: Statistics Canada (Dominion Bureau of Statistics) Publications 92-543, 92-611 and 92-716

Table 7

Alberta Population by Census Division - 1961 to 1971

Census Division #	Name	1961 Total	%	1966 Total	%	1971 Total	%
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	Medicine Hat	39,140	2.9	38,858	2.7	39,145	2.4
2	Lethbridge	83,306	6.3	82,719	5.7	86,620	5.3
3	Cardston	30,967	2.3	29,592	2.0	30,940	1.9
4	Hanna	15,020	1.1	14,224	1.0	12,990	0.8
5	Drumheller	38,115	2.9	35,987	2.5	34,485	2.1
6	Calgary	317,989	23.9	369,140	25.2	447,075	27.5
7	Wainwright	40,837	3.1	40,833	2.8	38,330	2.4
8	Red Deer	76,533	5.7	83,912	5.7	85,635	5.3
9	Mountains	20,274	1.5	18,122	1.2	19,780	1.2
10	Camrose	70,177	5.3	70,211	4.8	65,535	4.0
11	Edmonton	410,679	30.8	476,053	32.5	552,460	33.9
12	Ft. McMurray	47,310	3.6	50,635	3.5	54,645	3.4
13	Athabasca	45,431	3.4	44,142	3.0	43,785	2.7
14	Edson	19,282	1.4	20,431	1.4	21,665	1.3
15	Peace River	76,884	5.8	88,344	6.0	94,760	5.8
Total	-	1,331,944	100.0	1,463,203	100.0	1,627,875	100.0

Source: Statistics Canada

FIGURE 2

Province of Alberta Census Divisions

Table 8

Alberta 18-24 Population by Census Division - 1961 to 1971

Census Division #	Name	1961 Total	%	1966 Total	%	1971 Total	%
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	Medicine Hat	3,282	2.6	3,912	2.4	4,135	2.1
2	Lethbridge	7,196	5.7	8,965	5.5	10,520	5.2
3	Cardston	2,651	2.1	3,097	1.9	3,410	1.7
4	Hanna	1,136	0.9	1,304	0.8	1,270	0.6
5	Drumheller	3,030	2.4	3,586	2.2	3,560	1.8
6	Calgary	30,931	24.5	42,218	25.9	59,400	29.4
7	Wainwright	3,409	2.7	3,912	2.4	3,795	1.9
8	Red Deer	7,827	6.2	9,291	5.7	9,505	4.7
9	Mountains	1,641	1.3	2,119	1.3	2,655	1.3
10	Camrose	6,312	5.0	6,520	4.0	5,905	2.9
11	Edmonton	42,293	33.5	57,541	35.3	75,310	37.2
12	Ft. McMurray	4,040	3.2	4,890	3.0	5,510	2.7
13	Athabasca	3,158	2.5	3,749	2.3	3,845	1.9
14	Edson	1,767	1.4	2,119	1.3	2,425	1.2
15	Peace River	7,575	6.0	9,780	6.0	10,975	5.4
Total		126,248	100.0	163,003	100.0	202,250	100.0

Source: Estimated from Statistics Canada data.

cohort, these figures have been estimated from 15 to 19 and 20 to 24 age group data. An examination of Table 8 will reveal that while total 18 to 24 population has increased dramatically, in a number of census divisions (numbers 4, 5, 7, and 10 in particular), absolute declines have been experienced. Inter-census division mobility is high in Alberta and the direction of migration is toward the larger urban centres for this age group in particular.

Advanced Education Participation

Full-time enrolment in Alberta Advanced Education institutions more than tripled in the decade from 1961 to 1971, increasing from 11,133 full-time students in the 1961/62 academic year to 40,856 in 1971/72. By 1973/74 a further 2,643 students were reported. A summary of enrolments, by type of institution is provided in Table 9. With the exception of those reported for Regional Colleges, for which Winter semester student counts are shown, the enrolments described are full-time Fall enrolments in each year.

A comparison of the data in Table 9 with the population information in Table 6 indicates that post-secondary educational participation as reflected by growth in enrolments has more than kept pace with population growth. Over the decade 1961 to 1971 the 18 to 24 age group population increased by 60 percent while total provincial population increased by 22 percent. Enrolments in Advanced Education subsystems increased by 350 percent in Universities, 525 percent in Public Colleges, 190 percent in Regional Colleges and 420 percent in Technical Institutes programs, for an overall increase of more than 350 percent. These increases are expressed in terms of participation rates in Table 10.

Table 9

Full-time Enrolments in Advanced Education Institutions by Census Division - 1961/62 to 1973/74

		Public Colleges				
Year	Universities	University Transfer	Diploma & Other	Regional Colleges	Techncial Institutes	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1961/62	8,251	174	747	343	1,618	11,133
1962/63	9,149	168	703	394	1,724	12,138
1963/64	10,293	262	946	432	2,401	14,334
1964/65	11,921	475	1,287	497	2,816	16,996
1965/66	13,542	717	1,403	590	3,535	19,787
1966/67	15,597	798	1,541	550	4,169	22,655
1967/68	18,645	556	1,985	540	4,773	26,499
1968/69	22,976	781	2,055	667	5,829	32,308
1969/70	26,577	838	2,424	671	5,765	36,275
1970/71	28,991	1,152	2,946	646	6,265	40,000
1971/72	28,634	1,155	3,659	651	6,757	40,856
1972/73	27,613	1,110	4,475	705	7,535	41,438
1973/74	28,888	1,080	4,850	816	7,865	43,499

Source: Records of the Department of Advanced Education, The Alberta Colleges Commission, The Alberta Universities Commission and reports from institutions.

Table 10

Participation Rates[1] in Advanced Education Programs - 1961/62 to 1971/72

Program area	1961/62	1966/67	1971/72
(1)	(2)	(3)	(4)
Universities	.065	.096	.142
Public Colleges			
University Transfer	.001	.005	.006
Diploma & Other	.006	.009	.018
Total Public Colleges	.007	.014	.024
Regional Colleges	.003	.003	.003
Technical Institutes	.013	.026	.033
Total Full-time	.088	.139	.202

Notes: 1. Participation ratio calculated by dividing full-time enrolment by 18 to 24 age group population.

It is evident that increasing population is but a partial explanation for full-time enrolment increases in the 1961/62 to 1971/72 period. During this decade and into the Seventies, the expansion and development of the Advanced Education system, and the Public Colleges subsystem in particular, has been guided by a policy of increasing the accessibility of programs and services to residents of the Province. In particular, attempts have been made to extend programs geographically through the establishment of institutions outside of the major metropolitan centres of Calgary and Edmonton to provide for an increase in participation of those potential candidates for post-secondary programs who, for one reason or another, cannot or do not wish to change their place of residence in order to attend. Although more complete data through which progress in the achievement of this objective might be evaluated is not available, the sub-provincial analyses summarized in Tables 11 and 12 give some indication of the extent to which participation in full-time studies would appear to be dependent upon institutional proximity. Exceptions to this generalization are in areas where programs are specialized to the extent that opportunities are available at few locations.

The utility of the participation approach as an aid to policy planning and analysis is illustrated by the above. But in addition to its use in evaluating the achievement of objectives for the system, the approach may inform decisions regarding institutional or geographic priorities for the location and extension of services. For example, although often assumed to be the least well served in terms of program opportunity, Census Divisions 1 and 2 in 1971/72 had full-time participation rates higher than all other areas, including the urban centres

Table 11

Full-time Enrolments in Alberta Advanced Education Institutions by Census Division - 1971/72

Census Division # (1)	Name (2)	University of Alberta (3)	University of Calgary (4)	University of Lethbridge (5)	Grande Prairie Regional College (6)	Grant MacEwan Community College (7)	Red Deer College (8)	Mount Royal College (9)	Medicine Hat College (10)	Lethbridge Community College (11)	Fairview College (12)	Vermilion College (13)	Olds College (14)	N.A.I.T. (15)	S.A.I.T. (16)	Total (17)
1	Medicine Hat	136	168	62	-	2	5	9	382	28	-	-	12	27	74	905
2	Lethbridge	320	218	862	-	5	1	29	9	470	-	3	38	32	115	2,102
3	Cardston	95	109	137	-	1	-	19	-	150	-	-	10	12	35	568
4	Hanna	29	67	3	-	1	14	15	3	3	-	-	20	16	43	214
5	Drumheller	56	211	12	-	1	7	60	-	12	-	-	32	16	95	502
6	Calgary	891	6,900	27	-	8	44	1,151	1	20	-	2	100	67	1,944	11,155
7	Wainwright	198	35	4	-	6	30	16	1	5	-	18	16	123	22	474
8	Red Deer	488	170	7	-	6	450	29	-	8	-	3	44	126	118	1,449
9	Mountains	65	91	18	-	2	-	15	-	18	-	1	-	20	39	269
10	Camrose	732	20	5	-	17	32	22	-	6	-	47	12	234	37	1,164
11	Edmonton	11,951	162	23	-	183	110	158	4	12	1	17	28	1,983	93	14,725
12	Ft. McMurray	334	11	5	-	9	9	14	-	2	-	38	2	133	6	563
13	Athabasca	318	18	1	-	12	6	7	-	8	2	15	4	180	6	577
14	Edson	140	11	-	-	8	4	2	-	1	-	2	4	45	3	220
15	Peace River	422	36	5	297	13	17	22	-	2	73	3	11	140	27	1,068
Total Alberta		16,175	8,227	1,171	297	274	729	1,568	400	745	76	149	333	3,154	2,657	35,955
Other Provinces		1,074	636	37	21	124	43	274	42	130	6	15	60	408	375	3,245
Other Countries		994	310	10	18	12	7	50	-	80	1	1	10	99	64	1,656
TOTAL FULL-TIME		18,243	9,173	1,218	1,336	410	779	1,892	442	955	83	165	403	3,661	3,096	40,856

Source: Records and reports of the Alberta Universities Commission and the Alberta Colleges Commission.

Table 12

Participation Rates in Advanced Education Institutions
by Census Division - 1971/72

Census Division # (1)	Name (2)	University of Alberta (3)	University of Calgary (4)	University of Lethbridge (5)	Grande Prairie Regional College (6)	Grant MacEwan Community College (7)	Red Deer College (8)	Mount Royal College (9)	Medicine Hat College (10)	Lethbridge Community College (11)	Fairview College (12)	Vermilion College (13)	Olds College (14)	N.A.I.T. (15)	S.A.I.T. (16)	Total (17)
1	Medicine Hat	.033	.041	.015	-	.000	.001	.002	.092	.007	-	-	.003	.007	.018	.219
2	Lethbridge	.030	.021	.082	-	.000	.000	.003	.001	.005	-	.000	.004	.003	.011	.200
3	Cardston	.028	.032	.040	-	.000	-	.006	-	.044	-	-	.003	.004	.010	.167
4	Hanna	.023	.053	.002	-	.001	.011	.012	.002	.002	-	-	.016	.013	.034	.169
5	Drumheller	.016	.059	.003	-	.000	.002	.017	-	.003	-	-	.009	.004	.027	.141
6	Calgary	.015	.116	.000	-	.000	.001	.019	.000	.000	-	.000	.002	.001	.033	.188
7	Wainwright	.052	.009	.001	-	.002	.008	.004	.000	.001	-	.005	.004	.032	.006	.125
8	Red Deer	.051	.018	.001	-	.001	.047	.003	-	.001	-	.000	.005	.013	.012	.152
9	Mountains	.024	.034	.007	-	.001	-	.006	-	.007	-	.000	-	.008	.015	.101
10	Camrose	.124	.003	.001	-	.003	.005	.004	-	.001	-	.008	.002	.040	.006	.197
11	Edmonton	.159	.002	.000	-	.002	.001	.002	.000	.000	.000	.000	.000	.026	.001	.196
12	Ft. McMurray	.061	.002	.001	-	.002	.002	.003	-	.000	-	.007	.000	.024	.001	.102
13	Athabasca	.083	.005	.000	-	.003	.002	.002	-	.002	.001	.004	.001	.047	.002	.150
14	Edson	.058	.005	-	-	.003	.002	.001	-	.000	-	.001	.002	.019	.001	.091
15	Peace River	.038	.003	.000	.027	.001	.002	.002	-	.000	.007	.000	.001	.013	.002	.097
Total Alberta		.080	.041	.006	.001	.001	.004	.008	.002	.004	.000	.001	.002	.016	.013	.178

Source: Records and reports of the Alberta Universities Commission and the Alberta Colleges Commission.

of Calgary and Edmonton. Further, while some institutions, especially the Public Colleges, appear to draw students primarily from a more immediate geographic area, others (Olds College, the Technical Institutes) draw proportionately from the entire Province.

The approach has two serious limitations, however, as a projection methodology. First, its use is highly dependent upon accurate forecasts of population in a particularly mobile age group. Second, it is difficult to relate changes in the participation parameters to short-run fluc-fluctuations in enrolment patterns in both the secondary system and the Advanced Education network. Never-the-less, it can become a valuable aid to planning, especially, in program areas where program capability and facilities must be provided in order to tap latent demand. In addition, the participation approach provides an independent means to evaluate and validate projections derived by other means.

CHAPTER IV

ANALYSIS OF THE SYSTEM

Although educational planning is undertaken in support of numerous objectives, by far the most demanding set of problems is encountered in the resource acquisition and allocation areas. In each area, enrolment information, historical, present and future, for resource planning, is an important need. Two general approaches may be taken to educational development and some elements of each are reflected in Alberta's system. Under a "manpower planning" approach an attempt is made to limit, channel and/or induce enrolments to achieve national, provincial or sub-provincial manpower objectives. Under an alternative "demand satisfaction" approach, most planning activities focus on the removal of constraints and barriers to participation and the development of programs and facilities to meet the public's full aggregate demand for educational services. For a student flow model to be of utility to planners and decision makers at the program, institutional or system level, it must account for the policies and variables associated with both or either of these approaches and provide a valid representation of the real world system in terms of both structure and content. The analysis of the system presented in this chapter is directed at exposing the real world variables involved, their inter-relationships and other factors which affect student enrolment and flow processes.

For the purposes of this analysis, the term enrolment process will be used to denote the aggregate movement of students into, through and from programs and institutions. A model of this process will be called

an enrolment model. At the heart of the enrolment model, the process through which enrolments are generated will be referred to as the admissions process. The term student flow will be reserved for the process and model describing the movement, over time, of students to, through, among and from institutions in the Alberta System.

The Admissions Process[1]

Within the enrolment process, there exists a linear sub-process through which potential applicants are differentiated from a more general population, induced to apply, are admitted to an institution or program become attendees and therefore, enrolments. Such a process is represented conceptually in Figure 3 as a linear process in which pools of students, generated at each stage from a previous pool, are seen as generally decreasing from one stage to the next.

At each stage in the process, specific policies and activities have the effect of increasing, constraining or decreasing the numbers involved. The model assumes the existance of a population of an age generally appropriate to post-secondary program participation. Out of this population pool, individuals of which may be in the labour force or the non-labour force complement excluding educational attendees, a Potential Applicant pool is generated. The size and nature of this pool is primarily a function of the nature of the program in relation

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[1] The conceptualization of this process and that described in the following section follows the approach proposed by Lovell in C.C. Lovell Student Flow Models - A Review and Conceptualization (Preliminary Edition (Boulder, Colorado: National Centre for Higher Education Management Systems at Western Interstate Commission for Higher Education, August 1971).

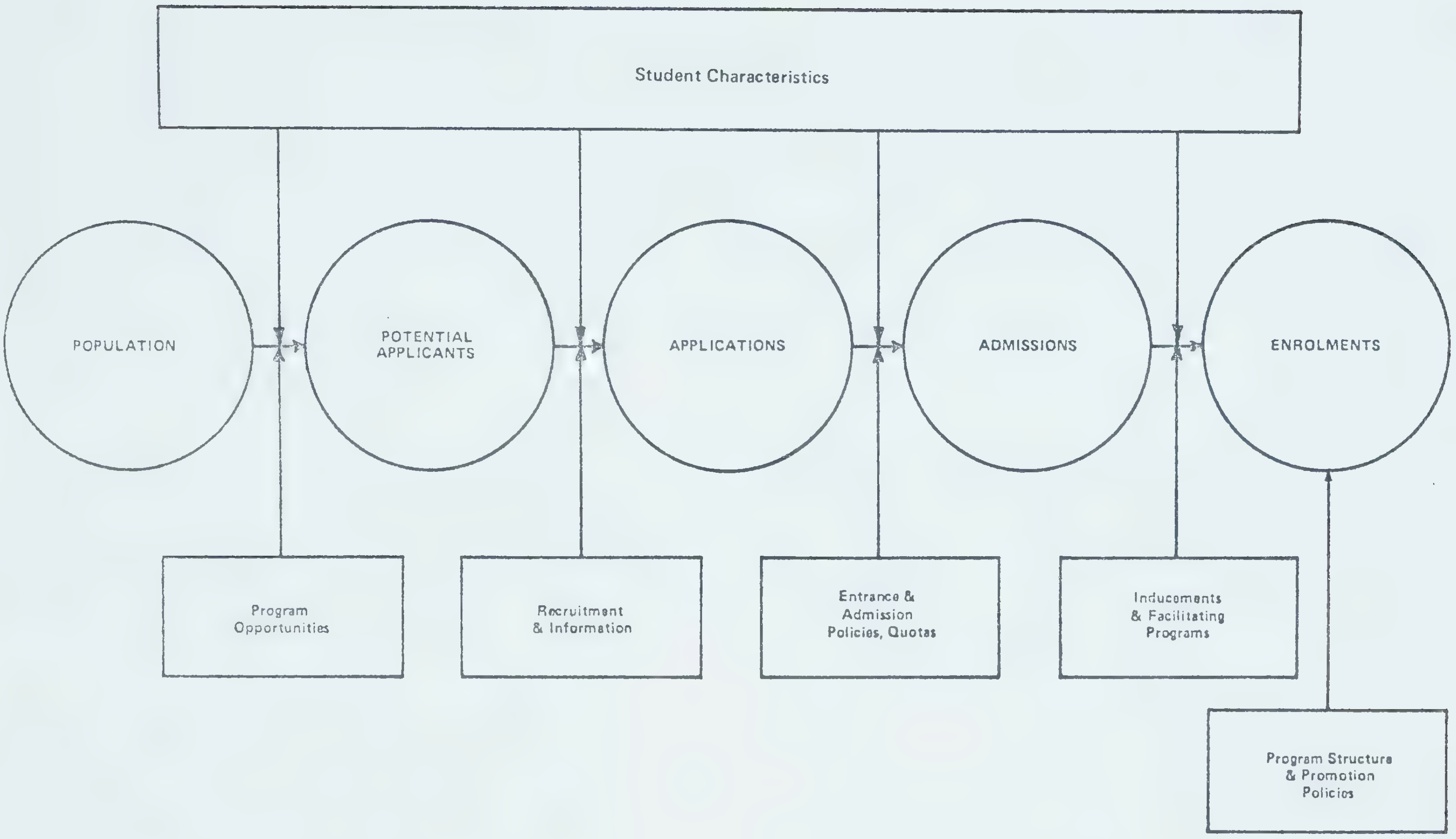

FIGURE 3

The Admissions Process

to the population. Applications, in turn, are a function of the effectiveness of recruitment and information programs employed to induce applications as well as the size and nature of the Potential Applicant pool. Some proportion of applicants are admitted as a function of entrance and admission policies including such limiting factors as enrolment quotas which may be based on facilities capacity or manpower demand factors. The number of admitted students who actually attend a program may depend upon the offering of certain inducements such as scholarships, student housing, recreational opportunities or campus amenities. Financial assistance to students facilitates attendance as do fellowships and assistantships at a graduate level. In addition, since the Enrolment pool includes students in multi-year programs, program structure and promotion policies are important factors. Throughout the process, such characteristics of students in the system as sex, age, employment and educational status, etc., act as conditioning variables.

The Enrolment Process

The conceptual schematic in Figure 4 places the Admissions Process in its larger system framework. Here, the various conditions under which a student can enter or re-enter an institution or program are distinguished and various pre-entrance states, including High School attendance, Other Institution attendance, and General Population (not participating in educational programs) are defined. The General Population state, in particular, may be sub-defined to recognize Labour Force participation, Employed and Unemployed; and Non-Labour Force Population as entry states. In addition, a geographic origin distinction may be made, such as in-province/out-of-province or classification by census division, depending upon the nature of admissions policies

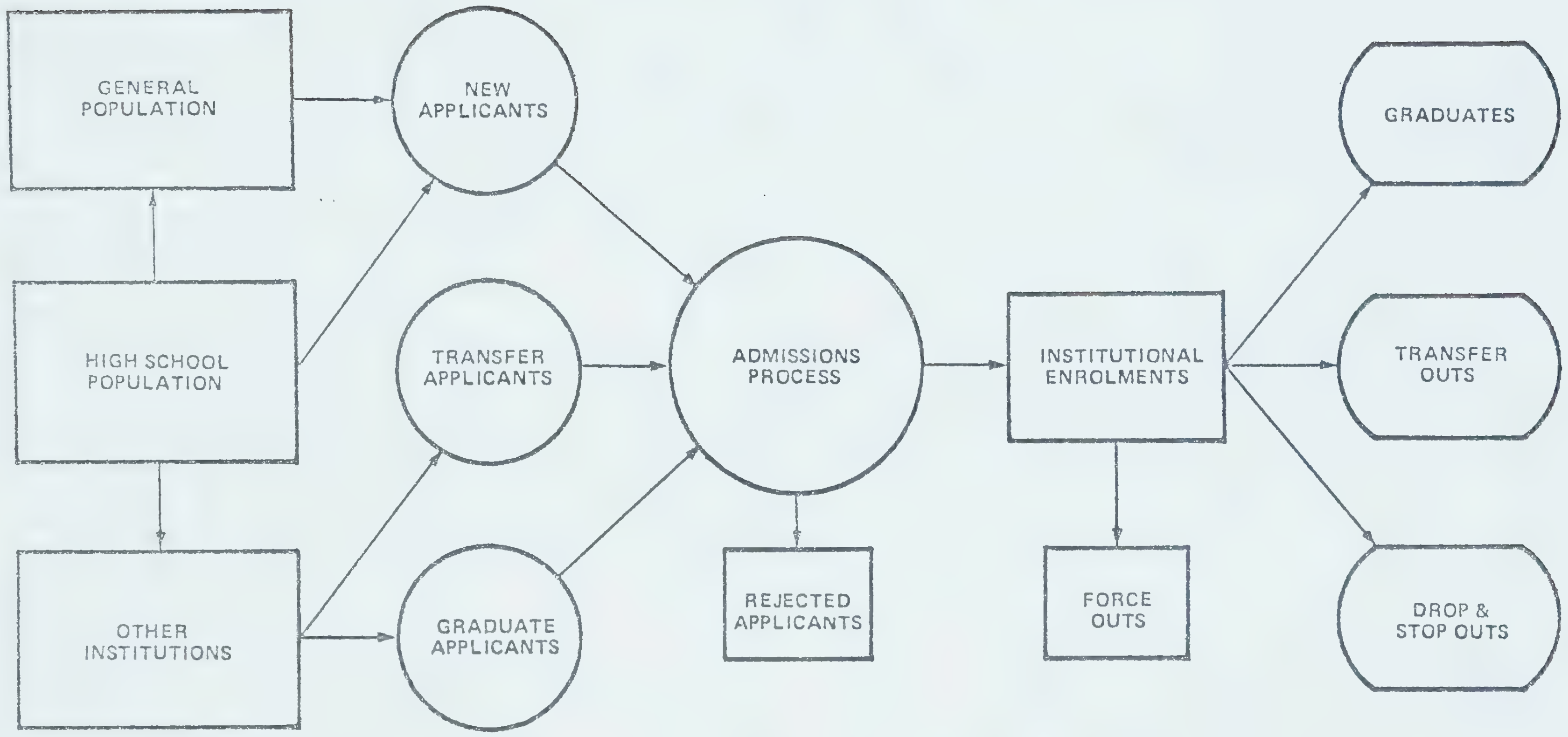

FIGURE 4
The Enrolment Process

involved. Further, and for analytical purposes, it may be useful to sub-define General Population on a specific year of age or an age group basis to provide for the kinds of analysis suggested in Chapter III to have an impact on a specific formulation of a model.

A component of the conceptual model depicted in Figure 4 requires a special elaboration. Within the input-output processes involved in the movement of students to and from a state of participation, the progression of students through various levels of a program and between alternative fields of study can be especially complex. Figure 5 is a schematic representation of such movements within an hypothetical institution having three three-year programs. Further elaboration from the perspective of a single program and year is provided in Figure 6. Specific sources and sinks are identified and possible flows to and from various programs are recognized.

Taken together, the processes described thus far represent the movements of students to, through and from a typical post-secondary institution in the Province.

The Student Flow Process

It was previously stated that the term student flow would be reserved for the processes through which students enter, move among and depart from the Alberta System of Advanced Education institutions and programs. Given the institutional enrolment processes, it is necessary to conceptualize the student flow process at the System level. Here, it must be recognized that the Advanced Education system is in reality a sub-component of a larger set of interrelated processes. From the student flow perspective, a post-secondary education system

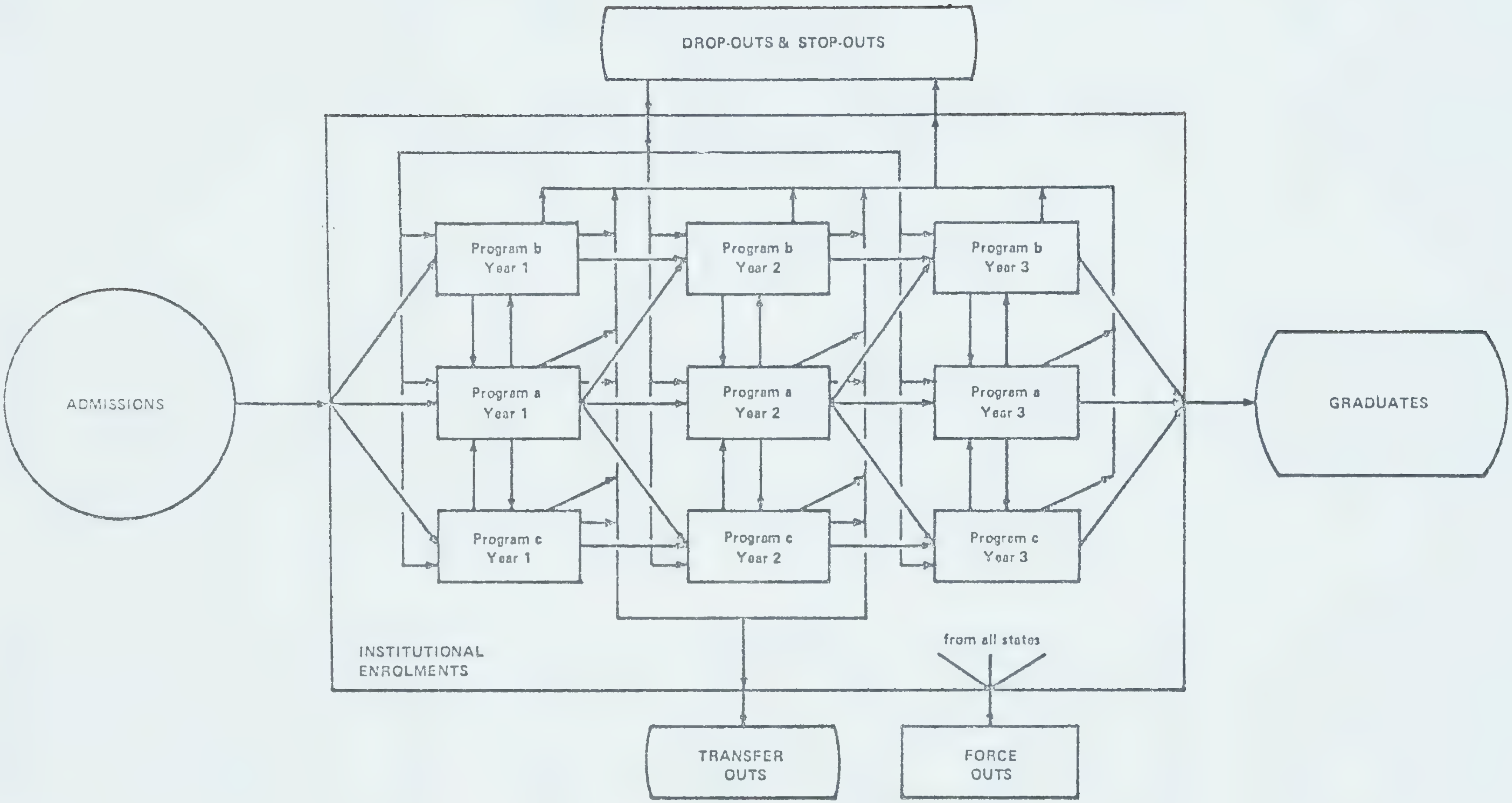

FIGURE 5

The Institutional Enrolment Process

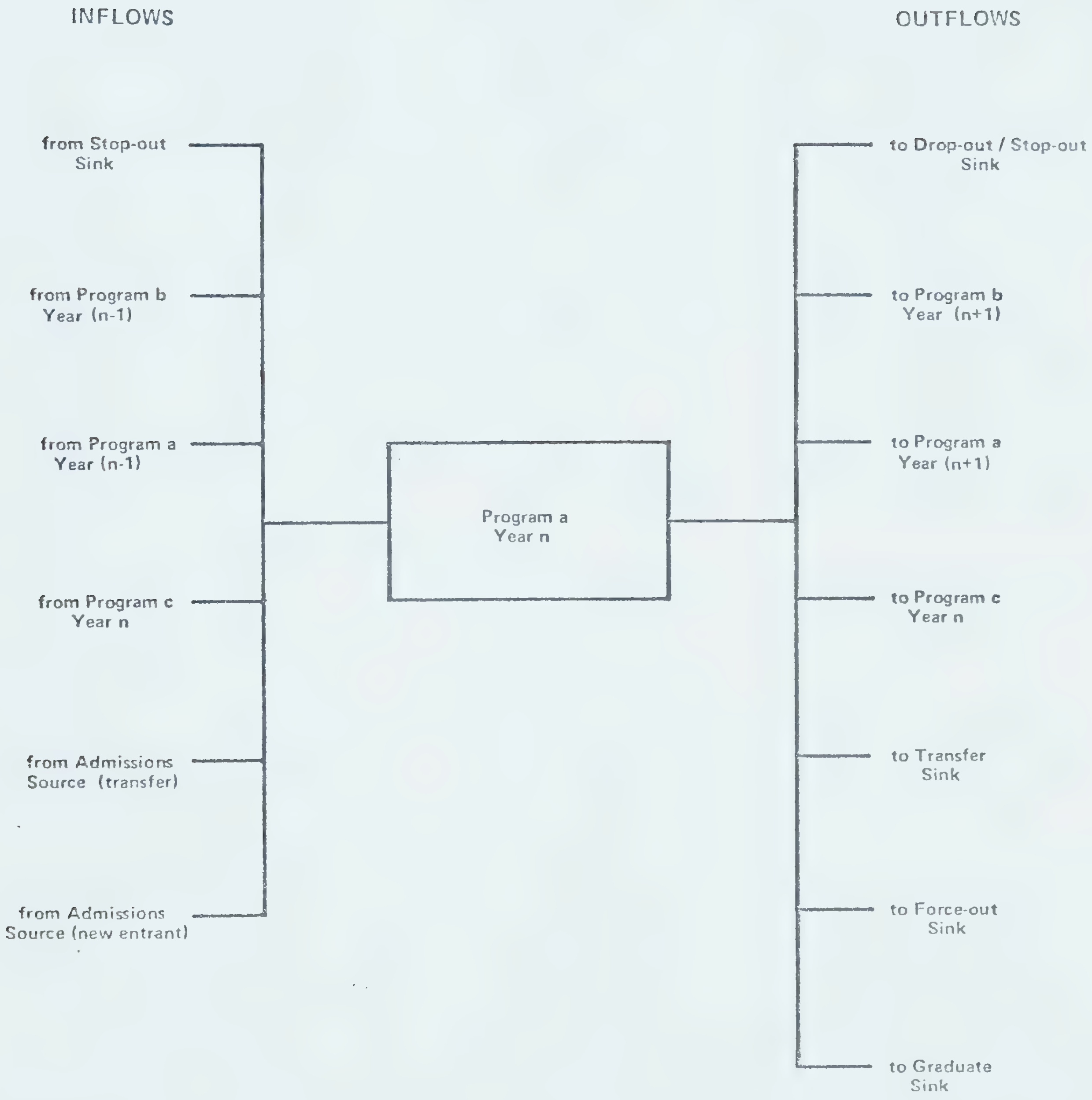

FIGURE 6

The Basic Flows

is interrelated with immigration and emmigration processes, with population dynamics, with Basic (Primary and Secondary) education systems, and with dynamic processes in the jurisdiction population base and the labour force. Figure 7 is a general schematic representation of a Student Flow process, specifying these inter-relationships.

The conceptualization described in Figure 7 views the Student Flow system as an interrelated set of mutually exclusive parts (states), which includes the various grade-levels of primary and secondary education, non-participating (in educational programs) provincial population subdivided into labour force (employed and unemployed) and non-labour force components, and the post-secondary system. The complexity of the latter was described in Chapter II. An elaboration of this system in Figure 8 provides information regarding primary flows of students internal to post-secondary education.

The question of relationships between educational participation and attendance and economic conditions, either the general state of the economy or supply/demand conditions in the labour market, has not been specifically addressed in the above conceptualization of a Student Flow process or the preceeding analysis of a subsumed Admissions and Enrolment Processes. In the Flow analysis, single "catch-all" states are used to represent a number of possible states not defined explicitly. The structure described is general enough that these "catch-all" states can be subdivided to permit the recognition of interdependencies between internal flow variables and external economic or other variables. For instance, Labour Force states can be subdivided in such a way as to describe various categories of manpower utilization and these matched with various post-secondary program categories. Thus, information

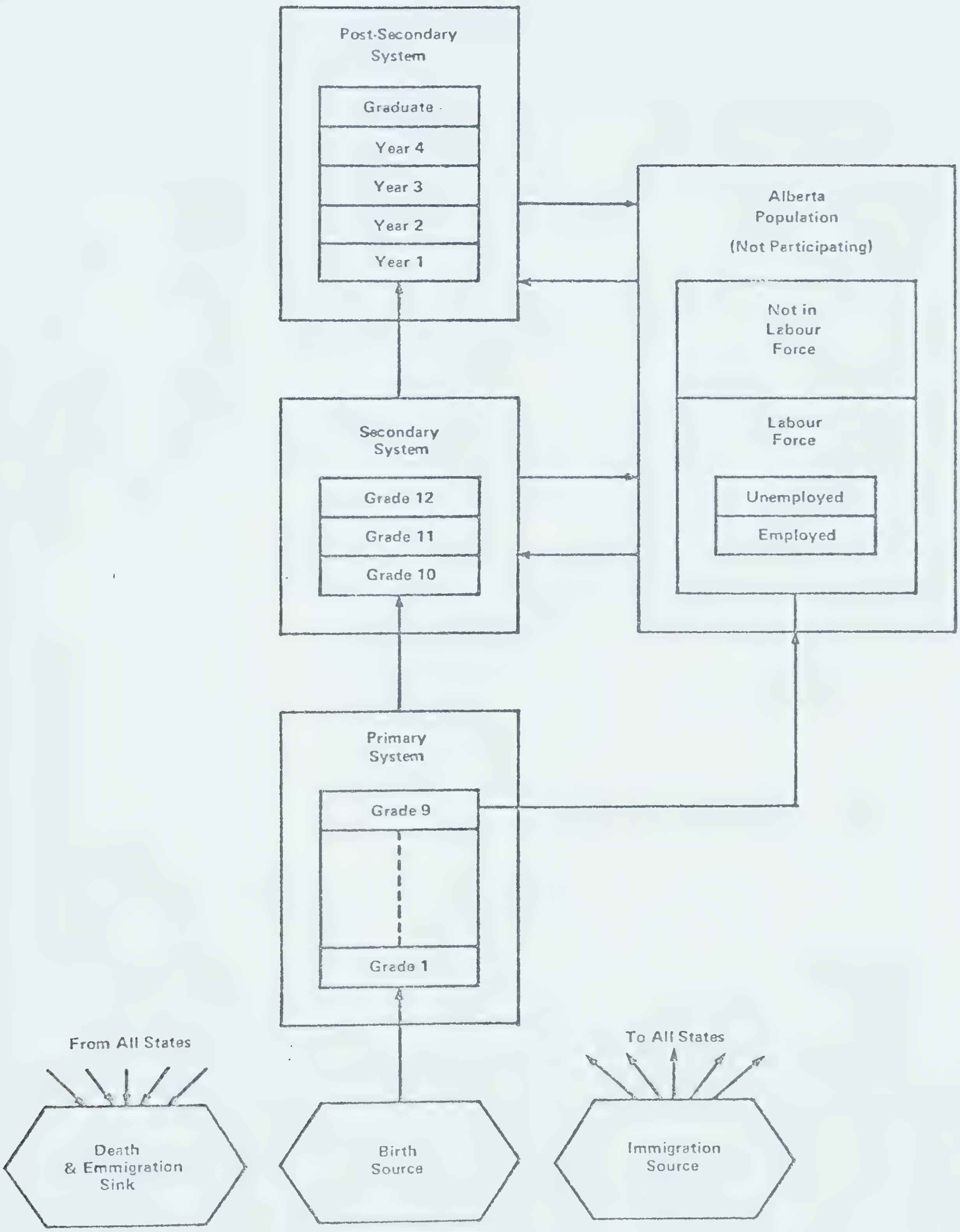

FIGURE 7

The Student Flow Process

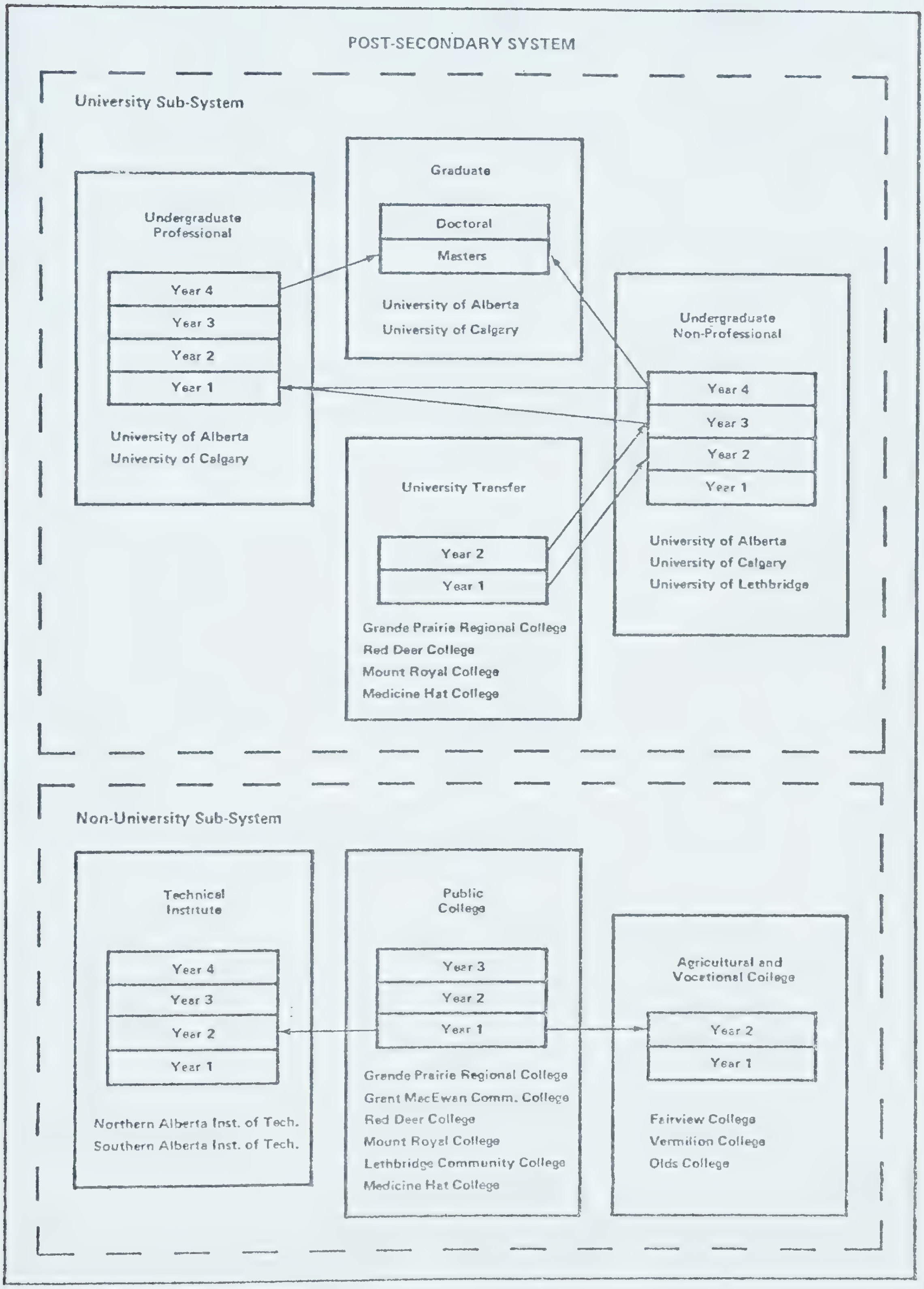

FIGURE 8
Primary Flows within Alberta Advanced Education

regarding the relationship of supply and demand conditions in a particular occupational category to student flows can be either made available in an analytical sense or brought to bear if a formulated model is to be used in a simulative or predictive fashion.

CHAPTER V

FORMULATING A MODEL

The primary purpose behind the development of a Student Flow Model for a system of post-secondary education is the aiding of educational planners in formulating and evaluating alternative policies and courses of action and making resource allocation and utilization decisions at program, institutional and system levels. Although the objects of the study being reported did not include the building and testing of specific model, ultimately, any model developed will require evaluation on the basis of both validity and practicability. The terms of reference of this study, however, did include an evaluation of the "state-of-the-art" and an analysis of the Alberta system including recommendations regarding the kind of appropriate model or set of techniques which should be considered. Before describing a general approach, it would appear useful to describe certain criteria the formulation to be suggested, or alternative models, may be evaluated.

Evaluating a Model

The problem of evaluating a model of the nature being contemplated for the Alberta system focuses on the assessment of both the validity and the practicability of any particular formulation. The validity of a model may be assessed through an application of the following tests:

1) Content validity. Content evaluation involves the subjective evaluation of whether or not necessary and sufficient components of the real world system being modeled have been provided for in the formulation.

2) Construct validity. A model of any real world system will normally include some expressions of relationship between interdependent variables which represent relationships in the real system whose nature is unkown but whose effects are measurable. Construct evaluation involves an assessment of the relative utility of including any particular representative relationship as opposed to an alternative.

3) Concurrent validity. The concurrent validity of a model is the degree to which the behaviour of the model is similar to the behaviour of the system being modeled.

4) Predictive validity. The predictive validity of a model can be assessed by comparing events or outcomes predicted by the model with occurrences in the real system being modeled; correspondence is a measure of predictive validity.

The practicability of a particular formulation can be evaluated on two bases:

1) Communicability. The time and effort involved in building a sophisticated model for simulative and predictive purposes is usually warranted only if the product has a high probability of being used and valued by decision makers. Acceptance by the non-technical policy and decision-maker is highly dependent upon the user having a clear understanding of the model and its utility. This factor alone will often dictate the selection of relatively simple approaches, even at some loss of explanatory or predictive power. Generally, the large scale sophisticated model and its output are of

such quantity and/or complexity that the user has little chance of gaining an understanding of even the important variables in the system and their inter-relations.

2) Data requirements and availability. A significant limiting factor in the development of a model is the availability of historical and current data. In addition, the problems associated with gathering data and maintaining a data base are formidable. Further, costs associated with running the model and processing input and output data become a significant consideration as the size and complexity of the formulation is increased. When all factors are considered, it may be advantageous to make a trade-off of marginal decreases in precision and/or predictive validity for increased adaptability with respect to both data availability and portability. Optimally, the versatility of a model, providing for the utilization of data at a more detailed level in an institutional application, and with minimum adaptation, more aggregated data in a system-level application, may be extremely desireable.

The general formulation to be described has been selected on the basis, primarily, of its practicability. In the sections which follow, a mathematical formulation will be proposed, the problem of parameter estimation discussed, and data requirements and availability examined.

A Mathematical Model

Of the various approaches to formulating student flow and enrolment forecasting models, those drawing upon the mathematical structure of the Markov Process appear to be the most popular. In the classical

Markov Process situation, subjects within a population are distributed into a set of mutually exclusive categories or "states". A stochastic matrix of transition probabilities is employed to represent flows from a contributing state vector to an accepting state vector. The basic assumption underlying the Process is that transitions from any state to another, depend only upon the present status of the system and are independent of the past. Thus, a discrete time system can be characterized by the matrix set of probabilities, one for each of the transitions from a present state to a possible state at a next point in time. An additional assumption is made with respect to the stationarity of the process; that is, that there exists a constant (independent of time) matrix of transition probabilities for the population of interest.[1]

Markov models can be included in the class of linear probability models. In such models, although ratios are used to represent the expected proportion of subjects in a population who move from one state to another during a given time interval, the general approach need not involve satisfying assumptions so obviously restrictive as those involved in the classical Markov model. Creager[2] notes that relaxing the requirements for a classical Markov Process provides greater flexibility and realism in representing the educational process. In this way, a model based upon the transition matrix approach can provide an efficient solution to the problem of simulating and projecting student flows

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[1] Further description and elaboration of the Markov Process may be found in J.G. Kemmeny, Finite Markov Chains, (Toronto: Van Nos., 1969).

[2] J.A. Creager. "Use of Empirical Transition Matrices in Educational Research". Paper presented at American Educational Research Association Annual Meeting, Minneapolis, Minnesota, March, 1970.

and numbers, providing that the educational system can be described in terms of the necessary mutually exclusive states at an appropriate level of detail. Such a "Markov-type" approach will be used as a point of departure.

Given the conceptualizations of admissions, enrolment and flow processes described in Chapter 4, enrolments in Alberta Advanced Education programs at any point in time can be viewed as a distribution of students among various mutually exclusive states each representing a level or year of a particular program (or program area) at a particular institution. Identifying n categories of student distribution and permitting each to have a trivariate classification (level, program and institution), the distribution of students in the system at time t, where "t" may refer to a term, semester or year, may be represented by:

$$\underline{s}(t) = [s_1(t), s_2(t), \ldots, s_n(t)]'$$

where $s_i(t)$ represents the number of students in state i at time t.

If $p_{ij}(t)$ is defined to represent the proportion of students in the j^{th} state at time (t-1) who are in the i^{th} state at time t, then an n x n matrix

$$P(t) = [p_{ij}(t)], \quad i = 1, \ldots, n; \; j = 1, \ldots, n$$

can be used to describe flows among states for those students who are in the system during (t-1) and t. Since transitions to any given state are impossible from certain other states, many of the elements of P(t) will be zero.

The numbers and distributions of entrants to the system from the various sources of new entrants (or re-entrants) identified in Chapter IV are a function of admissions processes. If n(t) is defined to

represent the number of students arriving at time t and $\underline{a}(t) = [a_1(t), \ldots, a_n(t)]'$ is defined as a distribution vector for entrants where $a_i(t)$ is the proportion entering state i, then an entry vector can be represented by:

$$\underline{a}(t)\ n(t)$$

To permit the model to recognize entrants on a source specific basis, the entry vector can be modified to:

$$\underline{e}(t) = A(t)\ \underline{n}(t)$$

where, given m sources,

$$\underline{n}(t) = [n_1(t), \ldots, n_m(t)]'$$

and $n_i(t)$ represents the number of entrants from source i at time (t);

$$A(t) = [a_{ij}(t)], \quad i = 1, \ldots, n;\ j = 1, \ldots, m$$

and $a_{ij}(t)$ represents the proportion of entrants from source j who enter state i.

Given the above, flows of students to and through various programs and institutions can be represented by the difference equation:

$$\underline{s}(t) = P(t)\ \underline{s}(t-1) + \underline{e}(t)$$

This basic equation may be extended to higher order to provide for prediction of flows into future time periods:

$$\underline{s}(t+m) = \prod_{k=0}^{m} P(t+k)\underline{s}(t-1) + \prod_{k=1}^{m} P(t+k)\underline{e}(t) + \prod_{k=2}^{m} P(t+k)\underline{e}(t+1) + \ldots.. + \underline{e}\ (t+m)$$

The matrix product $\prod_{k=i}^{m} P(t+k)$ is a flow descriptor for a time span of m - i + 1 time periods. If the pattern of flows is stable over time, so that P(t) = P for all t, the matrix product becomes P^{m-i+1}.

Parameter Estimation

Four major inputs are required to support the flow model described above:

(1) the number of students in various states of the system in the first time period being modeled (s)

(2) the number of entrants in each time period classified by source (n)

(3) the proportions of continuing students moving successive program levels, remaining at current levels and switching to other programs or levels, within and among institutions (P)

(4) the proportions of new entrants going to each institution-program-level combination (A)

The distribution of students among various system states, s, is initially determined from current (first time period) data. Once the model is initialized, this data is a product of successive iterations, requiring no special estimation.

Numbers of new entrants, or re-entrants, classified by source population, must be input to the model for each iteration or time period. Entrants from each source are represented by an element of n. These sources may include such potential entrant pools as Grade XII population, Labour Force, residual Provinical population, Immigration, etc., and further sub-classification on a geographic or age-specific basis may be desirable. For each source recognized, an appropriate method of estimation and/or prediction will be required. Depending upon methodologies chosen, projections of source populations may or may not be required.

The matrices P and A are similar in that each includes as elements the proportions of students in various system states and sources who move to other states in successive time periods. While precise determination of each requires individualized student record data, it should be possible to arrive at reasonable estimates using aggregate historical data, or to conduct analyses on the basis of carefully selected sample data from institutional records.

A number of methods and techniques for estimating appropriate values to place in P and A or in $\underline{n}$ are available. The more common of these include linear and non-linear least squares, exponential smoothing analysis of historical mean, last year's ratio or level and conjecture. The relative effectiveness of any procedure depends, in part, on the purpose to which the larger estimation or projection effort is being directed and, at the same time, on how far into the future projections are being made. Near-time estimates may safely be made using means analysis or smoothing, whereas longer-range analysis may call for techniques which recognize cyclic or trend factors and interactions with external variables.

Sensitivity testing of the total model is strongly recommended. Caution should be taken that over-sophistication of estimation procedures does not let the estimation problem dominate the modeling effort. Using a combination or a variety of procedures or techniques to inform a conjectural approach may, on balance, prove to be as effective a procedure, as any.

Impacting Variables

Three categories of variables having some influence on student decisions or a direct or indirect effect on patterns of flow through an educational system may be defined:

(1) Student characteristics variables
(2) System/institution control variables
(3) Exogenous variables

A list of examples of each is provided in Table 13. Student characteristics are the attributes that the student brings to the system, attributes which have some impact on the manner in which he enters and moves through the system. Control variables are those over which the system or institution have a degree of influence. It is in this area that the model can have a utility in addressing certain planning questions that derive from proposed changes. Finally, exogenous influences are those conditioning factors outside the system which may influence student decisions or facilitate decision-making.

As a first step towards adapting the formulation proposed to recognize the effects of impacting variables, it can be shown that the model implicitly recognizes departures from the system. Recalling that the relation

$$\underline{s}(t) = P(t)\underline{s}(t-1) + \underline{e}(t)$$

represents the flow of student population and that $P(t)$ represents student transitions, then

$$\sum_{i=1}^{n} p_{ij}(t)$$

represents the total proportion of students in state j at time (t-1) who are in state i at t, and

$$[1 - \sum_{i=1}^{n} p_{ij}(t)]$$

Table 13

Impacting Variables

Student Characteristics (1)	System Control Variables (2)	Exogenous Variables (3)
Sex	Program structure	Economic indicators
Age	Fee structure	Employment opportunity costs
Citizenship	Recruitment policies	Labour force characteristics
Immigration status	Information systems	Social variables
Geographic origin	Admissions policies	
Permanent residence	Quota systems	
Marital status	Financial aid structure	
Parental occupation	Housing structure	
Parental education	Major/Field requirements	
Previous education	Promotion policies	
Admission status	Graduation requirements	
Program status		
Financial aid		
Employment status		
Previous occupation		
Housing status		

represents the proportion who leave prior to time t.

Defining D(t) as an n x n matrix whose diagonal elements are

$$dj(t) = [1 - \sum_{i=1}^{n} p_{ij}(t)]$$

then a vector of departing students can be represented by

$$\underline{d}(t) = D(t)\underline{s}(t-1).$$

This kind of formulation may be used to reflect the importance of particular impacting variables where the effect of the variable is to "induce" attendance.

Let

$$L(t) = \begin{bmatrix} \ell_{11} & 0 & 0 & . & 0 \\ 0 & \ell_{22} & 0 & . & 0 \\ 0 & 0 & \cdot & & . \\ . & . & & . & . \\ 0 & 0 & . & . & \ell_{nn} \end{bmatrix}$$

represent the proportion of students who would leave (would not enter) the system were it not for such inducement as financial aid, student housing, etc. Assuming that L(t) is determinable, the flow equation becomes:

$$\underline{s}(t) = P(t)\underline{s}(t-1) + \underline{e}(t) - L(t)\underline{s}(t-1)$$

Another approach may be taken to increase the model's sensitivity to certain impacting variables, in particular, those variables which affect the behavioural decisions represented by the matrices P and A, for example, such student characteristics as sex, age, marital status, parental education and/or occupation or such exogenous influences as employment opportunity costs, economic indicators, etc. If P_o and A_o are thought of as representing the free-flow behaviour of those students for which no control or impact variable have been identified, then the population flow equation might become:

$$\begin{aligned}\underline{s}(t) &= P_o(t)\underline{s}_o(t-1) + P_1(t)\underline{s}_1(t-1)\\ &+ P_2(t)\underline{s}_2(t-1) + \ldots + P_n(t)\underline{s}_n(t-1)\\ &+ A_o(t)\underline{n}(t) + A_1(t)\underline{n}_1(t)\\ &+ A_2(t)\underline{n}_2(t) + \ldots + A_n(t)\underline{n}_n(t)\end{aligned}$$

where $P_i(t)$ and $A_i(t)$, $i = 1, 2, \ldots, n$, represent the effects of control or inducement through impacting variables.

Data Requirements

In previous sections the basic mathematical structure of a student flow model has been described. In addition, a number of options or variations have been discussed. Depending upon the specific combination of alternatives chosen for implementation, data requirements may be extensive or modest. While the maintenance of a data base is essential to supporting a student flow model, certain parameters of the model can be estimated through independent studies, thus reducing the amounts of data which will require maintenance on an individualized record basis.

Data requirements for the kind of approaches proposed here are summarized in Table 14. Specific data elements have been categorized as essential or desirable and comments with respect to elements are provided.

Table 14

Data Requirements

Data Element (1)	Importance Essential = E Desirable = D (2)	Comments (3)
Student-related:		
Student ID	E	- System-level preferred
Social insurance number	D	
Sex	D	
Birth date	D	
Citizenship	D	
Immigration status	E	
Geographic origin	E	- or Permanent home address
Marital status	D	
Housing status	D	
Highest educational attainment	E	
Mother's occupation	D	- may be obtained through independent survey
Father's occupation	D	
Mother's education	D	
Father's education	D	
Previous education:		
Institution	D	- may be obtained at time of admission to current institution
Program/Field	D	
Departure status	D	
Departure date	D	- separate blocks should be obtained for each experience
Financial aid	D	
Previous occupation	D	
Current education:		
Admission date	D	
Entry level	E	
Program/Field	E	
Admission status	D	
Current level	E	
Current program	E	
Financial aid	D	
Employment status	D	
Termination status	E	
Institution-related:		
Program structure	E	
Fee structure	D	
Financial aid structure	D	
Admissions policies	E	
Quota systems	E	
Promotion policies	D	
Major/Field requirements	D	
Housing structure	D	
Graduation requirements	D	
Exogenous data:		
High-school enrolments	E	
Labour force statistics	D	
Population projections	E	
Economic indicators	D	
Employment opportunity costs	D	
Social variables	D	

CONCLUSION

The basic purpose of this study was to review enrolment and student flow related aspects of the Provincial system of advanced education and to assess the feasibility of applying student flow modeling techniques to assist both policy evaluation and enrolment forecasting.

The study included an extensive survey of the system, conducted through personal interviews with senior institutional officials and co-ordinating agency personnel. This survey not only provided data with respect to the structure of the system and permitted an assessment of practices and capabilities, but also afforded the author an opportunity to gain insight into the uses to which enrolment forecast and student flow data is put, and the importance of such information.

Student flow and enrolment information is essential to program planning and review activities at all levels in the system. Enrolment projections and demand forecasts are critical to planning, budgeting and institutional levels. But in selecting appropriate tools and techniques, equal recognition must be given to the need for simulative tools to aid policy formulation and evaluation.

The approach suggested in this paper is a general one. Despite its generality, however, the approach meets important evaluation criteria. It accounts for students in terms of their location in various years of programs in various institutions and the structure of the system and provides for the relationship of impacting variables in conditioning student flows. The approach is relatively simple and can be implemented at the system level, at an institutional level or at a program level

without major modification. Implementation can be approached in a modular fashion and although a model based upon the approach can be easily programmed, the technique is not computer dependent. The approach can benefitially handle a large quantity of data, but at the same time is adaptable to a basic level of data availability.

Although, depending upon the specifics of any particular formulation, the parameters of any model developed may not require elaborate estimation techniques, the use of sophisticated approaches is not precluded and these can be selectively developed and employed without modifying the basic approach.

In addition to informing enrolment forecasts and projections, the approach can be used to develop a simulation model and the latter used to assess the effects of alternative decisions, policies or economic conditions on present and future enrolment levels and patterns. Also, the approach proposed leads to the identification of important relationships and the specification and maintenance of vital statistical data. Further, the approach leads to the provision of data in a form not requiring further interpretation or analysis in order to satisfy requirements of educational decision makers.

Although the approach described in this paper is recommended strongly as a basis upon which a system-level flow model may be developed, an important qualification should be noted. Enrolment forecasts and related policy decisions are probably best informed by a number of approaches. No single approach should necessarily be relied upon at either the system or institutional level. The approach to flow modeling proposed here has the advantage of lending itself well to a macro-analytical formulation through which, as required, micro-analytical studies or modules may be used in ancillary fashion.

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